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Guidance Manual for Hazardous Waste Incinerator Permits

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The manual provides guidance to the permit writer for designating facility - specific operating conditions necessary to comply with the RCRA standards for hazardous waste incinerators. Each section of the incineration regulation is addressed, including: waste analysis, designation of principal organic hazardous constituents and requirements for operation, inspection and monitoring. Guidance is also provided for evaluating incinerator performance data and Trial burn procedures.

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GUIDANCE MANUAL FOR HAZARDOUS WASTE INCINERATOR PERMITS

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GUIDANCE MANUAL FOR EVALUATING PERMIT APPLICATIONS FOR HAZARDOUS WASTE INCINERATORS

1.0 INTRODUCTION

This manual provides guidance for review and evaluation of the permit application information submitted to document compliance with the RCRA standards for incineration. Methods are suggested for designating facility-specific operating conditions necessary to ensure compliance with the standards, on the basis of the performance data supplied by the applicant. Each section of the incineration regulation is addressed, including: waste analysis, designation of principal organic hazardous constituents (POHCs) in the waste, and requirements for operation, inspection and monitoring. Guidance is also provided for evaluating incinerator performance data and the procedures used in an incinerator trial burn, during which performance data are generated.

The Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA) requires EPA to establish a national regulatory program to ensure that hazardous wastes are managed in a manner that does not endanger human health or the environment from the time the wastes are generated until their eventual destruction or final disposition. The statute requires EPA to:

> "...promulgate regulations establishing such performance standards, applicable to owners and operators of facilities for the treatment, storage or disposal of hazardous waste identified or listed under this subtitle, as may be necessary to protect human health or the environment." (42 USC 6964)

The incineration standards promulgated on January 23, 1981, and amended on June 24, 1982, specify three major requirements regarding incinerator performance. They are that the principal organic hazardous constituents (POHCs) designated in each waste feed must be destroyed and/or removed to an efficiency of 99.99%, that particulate emissions must not exceed 180 milligrams per dry standard cubic meter, corrected to 7% oxygen in the stack gas, and that gaseous hydrogen chloride (HCl) emissions must be reduced either to 1.8 kg per hour or at a removal efficiency of 99 percent. The regulations also specify a number of requirements for waste analysis and incinerator operation, monitoring and inspections. Finally, they establish the procedures by which permits to hazardous waste incinerators will be granted.

In addition to the standards for incineration, owners and operators of hazardous waste incinerators must comply with the general facility standards and administrative requirements for hazardous waste management facilities (40 CFR Part 264, Subparts A through H). These standards include requirements for: security, facility inspections, personnel training, special requirements for ignitable, reactive and incompatible wastes, facility location with respect to floodplains and areas of seismic activity, special equipment for emergency preparedness and prevention, a contingency plan and procedures to be used in an emergency, use of the hazardous waste manifest system, recordkeeping, reporting, and facility closure. They apply to all regulated hazardous waste treatment, storage and disposal facilities and all permit applications must ultimately include detailed descriptions of the equipment, plans and procedures required by these standards. Guidance for review and evaluation of the permit application information documenting compliance with the general facility standards and administrative requirements is provided in other RCRA guidance manuals.

1.1 Hazardous Waste Incinerator Permits

Each facility treating, storing, or disposing of hazardous waste must apply for and receive a permit which applies the regulatory standards to its particular circumstances and states its particular compliance obligations. RCRA allows existing facilities to operate during the period before a final permit decision is reached, provided that the owner or operator has made a timely submission of the required permit application. A facility is legally eligible for operation during this period, called the period of "interim status", only if it was in existence on November 19, 1980 and if the owner or operator submits a RCRA permit application.

Because of the large number of RCRA permits that must be issued, the permit application needed to qualify for interim status may be due years before the facility's individual permit will be considered. Requiring all of the information needed for a decision concerning the facility permit at the time of qualification for interim status would result in a requirement that owners and operators provide a great deal of information to the Agency long before it is needed for regulatory purposes. Furthermore, because of the lengthy period which ensues following qualification for interim status, information provided so far in advance might well be outdated by the time EPA begins to evaluate the permit application.

To avoid this result, EPA has divided the permit application into two parts. Part A, which is relatively brief, is filed by owners and operators of existing facilities in order to qualify for interim status. Part B of the permit application contains the balance of the information necessary to fully evaluate the facility's performance and reach a decision concerning issuance of a permit. EPA's standards for hazardous waste incinerators (40 CFR 264.340-264.351 and 40 CFR 270.19 and 270.62) specifically identify the information necessary to complete the Part B application for a hazardous waste incinerator.

Compliance with the standards for incineration of hazardous waste (40 CFR 264.340 through 264.351) may be initially established through performance of a trial burn. During the trial burn, the applicant tests the incinerator's ability to destroy the hazardous waste, or wastes to be treated at the facility, in compliance with the performance standards. Generally, the applicant's goal in conducting the trial burn should be to identify the most efficient conditions, or range of conditions, under which the incinerator can be operated in compliance with the performance standards. Often, this will require that the applicant test a range of operating conditions during the trial burn in order to identify the best conditions.

In order to establish compliance with the performance standard for 99.99% destruction and removal of organic waste constituents, the regulations provide for selection, by the permitting official (the "permit writer"), of principal organic hazardous constituents (POHCs) for each waste feed to be burned. POHCs are hazardous organic substances present in the waste feed which are representative of those constituents most difficult to burn and most abundant in the waste. The incinerator standards set out the criteria to be used in selecting POHCs (i.e., difficulty of incinerability and concentration). The destruction and removal efficiency is actually measured only for the designated POHCs. The incinerator's performance in treating POHCs is considered indicative of overall performance in treating other wastes. This provision simplifies the sampling and anlysis efforts which are necessary to determine whether the performance standard has been achieved, thereby reducing the cost and complexity of the trial burn.

Compliance with the performance standard for control of gaseous hydrogen chloride (HCl) emission is documented, during the trial burn, by measuring HCl in the stack gas. Similarly, compliance with the performance standard for control of particulate emissions is documented by measuring the particulate load in the stack gas during the trial burn.

Part B of the permit application for a hazardous waste incinerator may include a detailed plan describing the test procedures, sampling and analytical protocols and schedules for conducting a trial burn. This plan should be reviewed by the permit writer and approved if found sufficient to provide all necessary performance data. The trial burn plan is a required component of a permit application for a new incinerator.[1] Owners and operators of incinerators currently in interim status are not obligated to draw up a detailed trial burn plan for Agency approval prior to conducting the burn. Performance data may be collected in the course of routine operation during interim status. However, prior approval of a trial burn plan will provide the applicant with assurance that the information collected will be sufficient for preparation of the permit and that further data collection efforts are not likely to be necessary. Furthermore, careful planning of the trial burn will allow the applicant and Regional or State representative to design a permit that is well tailored to the specific needs of the facility and provides the greatest possible flexibility.

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[1] A "new" incinerator is one that was not in existence on November 19, 1980 and therefore does not qualify for interim status. The RCRA regulations stipulate that owners or operators of new incinerators must apply for and receive a RCRA permit before beginning construction.

The performance data collected during the trial burn are reviewed and evaluated by the permit writer and become the basis for settling the conditions of the facility permit. Generally, the operating conditions, or range of conditions, shown to result in acceptable incinerator performance (as defined by the performance standards) will be designated in the permit as allowable. The incinerator regulation requires that the permit specify:

- allowable waste analysis procedures;
- allowable waste feed compositions (including acceptable variations in the physical or chemical properties of the waste feed);
- acceptable operating limits for carbon monoxide (CO) in the stack exhaust gas;
- waste feed rate;
- combustion temperature;
- combustion gas flow rate; and
- allowable variations in incinerator design and operating procedures (including a requirement for cutoff of the waste feed during start-up, shut-down and at any time when the conditions of the permit are violated).

The permit must also specify actions necessary to control fugitive emissions from the incinerator, methods for continuous monitoring of operating parameters, and requirements for periodic inspection of the facility. Additionally, the incinerator regulation allows the permit writer to specify any other operating conditions necessary to assure that the performance standards are being met.

In reviewing and evaluating the permit application, it is essential that the permit writer make all decisions in a well-defined and well-documented manner. Once an initial decision is made to issue or deny a permit, the Subtitle C regulations (40 CFR 124.6, 124.7, and 124.8) require that either a statement of basis or a fact sheet be prepared which discusses the reasons for the decision. The statement of basis or the fact sheet then becomes part of the administrative record (40 CFR 124.9), which is to be made available for public review and comment as part of the permit review process (40 CFR 124.6 through 124.20).

1.2 Content of the Permit Application

The RCRA regulations allow incinerator owners and operators to select one of several options for completing a permit application. First, applicants seeking permits to burn wastes which are hazardous solely due to their ignitable, corrosive or reactive properties are eligible for exemption from most of the technical standards for incineration. These applicants are required to submit only the information required by the general and administrative standards, and a detailed waste analysis. Second, applicants not eligible for the exemption will be required to conduct a trial burn and submit the results of all stack sampling and analysis with the permit application. Third, as an alternative to conducting a trial burn, applicants may submit waste analysis data and data describing the performance of a similar incinerator burning a similar waste. This information will be evaluated to determine whether it can be used to predict the performance of the applicant's incinerator.

The information which must be submitted to show compliance with the standards for incineration consists of five components: waste analysis information, the facility description, the trial burn plan, performance data, and proposed operating conditions. Waste analysis information includes all sampling and analytical methods and plans for conducting both a detailed waste analysis and periodic waste analysis to verify that the waste feed composition entering the incinerator does not violate the conditions of the permit. The results of a detailed waste analysis should also be provided. This information will allow the permit writer to designate the principal organic hazardous constituents of the waste.

The facility description includes, at a minimum, the linear dimensions of the incinerator, capacity of the prime mover, description of the nozzle and burner design and the location and description of temperature, pressure and flow indicators and control devices. The applicant must also provide a description of the auxiliary fuel system, the automatic waste feed cutoff system, the air pollution control system and the stack gas monitoring system.

The trial burn plan should include a description of all sampling and monitoring procedures and equipment, a test schedule and protocol, a description of the range of operating conditions under which the incinerator will be operated, and a description of emergency procedures for waste feed cutoff, shutdown of the incinerator and control of emissions. The trial burn plan should discuss all methods planned for testing the components of the incinerator (e.g., waste feed mechanisms, monitoring devices, air pollution control devices). In addition, the waste feed(s) to be used during the trial burn should be described in detail. This is particularly important in cases where the applicant chooses to use a contrived blend of wastes or chemicals instead of the waste that will normally be treated at the facility. For more details on a contrived blend of wastes, refer to the discussion on artificial waste in Section 2.4.1 of this manual.

If performance data is included, the permit application will primarily consist of data collected during the trial burn. The applicant may supplement the trial burn data with data or information collected previous to the trial burn or with data generated by a similar incinerator. In some cases, the applicant may have extensive data from a trial burn conducted at a similar or identical incinerator burning a similar waste. This information, if sufficient to write the permit conditions, may be used in lieu of a trial burn (40 CFR 270.19(c)). At a minimum, the performance data should include:

- results of the waste analysis;
- results of the analyses of the scrubber solution, ash and other residues;
- computations of the destruction and removal efficiency;

- particulate emissions and HCl emissions;
- identification of any fugitive emissions;
- average, maximum and minimum temperatures and combustion gas flow rates; and
- results of any continuous monitoring.

Finally, the permit application should include a description of the conditions under which the applicant proposes to operate the incinerator. Each of the operating parameters identified in the regulations (40 CFR 264.345) should be addressed. This portion of the permit application will vary in detail and complexity, depending on the degree of flexibility desired in the permit conditions.

1.3 Permit Application Procedures

1.3.1 New Incinerators. Prior to construction of the incinerator, owners and operators of the new units who will conduct a trial burn are required to submit a trial burn plan with the permit application. The application will be processed through all of the required administrative procedures (40 CFR Part 124), including preparation of a draft permit and opportunity for public comment and hearing. After completion of this process, a permit that establishes all of the conditions needed to comply with all applicable standards will be issued. This permit will be the "finally effective RCRA permit" required (40 CFR 270(f)) for construction of the incinerator.

The permit will be structured to provide for four phases of the operation. Operating conditions will be specified for each phase. The initial phase begins immediately following completion of construction.

During this phase, the unit may be operated for "shake-down" purposes, in order to identify possible mechanical difficulties, and to ensure that the unit has reached operational readiness and has achieved steady-state operating conditions prior to conducting the trial burn. This phase of the permit is limited in duration to 720 hours of operation using hazardous waste feed (one additional period of up to 720 hours may be allowed for cause). Note that this does not limit burning of nonhazardous wastes or fuel.

After timely and satisfactory completion of all shake-down operations, the second phase of the permit begins. This phase consists solely of the period alotted for conducting the trial burn. Following completion of the trial burn, a period of several weeks to several months will be necessary for completion and submission of the trial burn results and subsequent specification of operating conditions to reflect the results. During this period, which represents the third operational phase of the permit, the facility may continue to operate under specified operating conditions.

Detailed review of the trial burn results will show either that the incinerator is capable of complying with the performance standards when operating within the trial burn conditions, or that compliance was not attained during the trial burn and a second test is necessary. If compliance was shown, the permit may be modified to set, as the final operating requirements, those conditions demonstrated during the trial burn. (See 40 CFR 122.17, "Minor Modifications of Permits"). If compliance has not been shown and an additional trial burn is necessary, the permit must be modified to allow for an additional trial burn. When all permit modifications are complete, the facility begins its fourth and final operating phase which continues throughout the duration of the permit.

Permit modifications may be major or minor modifications. Minor modifications are changes in the waste feed composition, operating conditions, or other permit stipulations that are within the range of allowable variations specified in a permit. Examples of minor variations are an increase in the heating value of a waste and an increase in combustion zone temperature. Minor permit modifications do not require review at a public hearing. Major permit modifications are changes that are outside the range of permitted values and equipment modifications that may affect incinerator performance. Examples of major modifications are a decrease in the heating value of a waste below the permitted value, a change in the monitoring location of combustion zone temperature, and replacement of a combustion chamber having different dimensions. Major modifications require review at a public hearing.

1.3.2 Existing Incinerators. The application procedure for existing facilities differs from new facilities because an existing facility in interim status is authorized to burn hazardous wastes. Therefore, an existing facility needs no prior approval to continue operation or conduct a trial burn. However, without the permit writer's approval, the owner or operator cannot be certain that the trial burn data will be sufficient to meet the permit writer's needs. Thus, the applicant will find it advantageous to obtain approval of a trial burn plan prior to conducting the test. During review of the trial burn plan, the permit writer will designate principal organic hazardous constituents (POHCs) to be monitored and will specify other requirements. However, the applicant may choose to collect data during the course of normal operation under interim status or may acquire data from similar facilities burning similar wastes to be submitted with Part B of the permit application in lieu of conducting a trial burn according to an approved trial burn plan.

Because RCRA provides for existing incinerators to operate under interim status while awaiting the Agency's decision concerning permit issuance, these facilities do not experience the operating restrictions which complicate the permitting process for new incinerators. Owners and operators of existing incinerators who will conduct a trial burn may submit a trial burn plan either before or with Part B of the permit application. The permit writer will evaluate the plan and approve it after making all necessary determinations (40 CFR 270.62)

If a trial burn plan is submitted and approved before the permit application has been submitted, the applicant should conduct the trial burn, and submit the resulting data with the permit application. If completion of this process conflicts with the date set for submission of the Part B application, the applicant should contact the permit writer to extend the date for submission of the Part B application, or submit the Part B without the trial burn results and provide the data within 90 days following completion of the trial burn. If a trial burn plan is submitted with Part B of the permit application, the permit writer, when approving the plan, will specify a time period for conducting the trial burn and submitting the results. Following submission of the trial burn results and the Part B application, the permit writer will prepare a draft permit specifying the proper operating requirements, based on the results of the trial burn, along with all other applicable permit conditions. This permit will then be processed through the standard administrative procedures (40 CFR Part 124).

1.4 Use of this Manual

The information and guidance presented in this manual constitute suggestions for review and evaluation, often based upon best engineering judgment. The guidance is intended to help resolve technical issues on a case by case basis, not to provide rigid rules to be applied in all circumstances. The responsibility for applying the regulations and specifying the permit conditions lies with the permit writer. This manual will assist the permit writer in arriving at decisions in a logical, well-defined, and well-documented manner. Checklists are provided throughout the manual to ensure that necessary factors are considered in the decision process. Several options for developing specific permit requirements are presented. The permit writer is not limited to adopting only one option and is encouraged to tailor permits to each applicant's situation. Technical data and numerical methods are presented to assist the permit writer in evaluating an incinerator. References are cited throughout this manual to aid the permit writer in those instances where further guidance is necessary.

In addition to this guidance manual, permit writers use the "Engineering Handbook for Hazardous Waste Incineration," EPA SW-889, IERL, Cincinnati, Ohio.(1) The Engineering Handbook provides background information to familiarize the permit writer with current incineration technology. Permit writers may also use the Hazardous Waste Incineration Data Base. This data base provides computer and hard copy access to trial burn data, permit application data and information from incinerator manufacturers. The data base is accessible at EPA regional offices and at EPA headquarters.

The permit writer may also require technical assistance in the evaluation of certain permit applications, especially those for which there are no precedents. To this end, the Agency has formed a Permit Assistance Team (PAT). The team consists of experts in the field of hazardous waste incineration. It has two primary functions: (1) to provide the Regional Offices with direct access to specialized expertise related to hazardous waste incineration, and (2) to provide EPA with increased capability to respond quickly when applications are received. The members of the PAT augment EPA staff capabilities concerning incineration hardware, facility design, analytical measurements and protocols, site survey and evaluation, and environmental impact modeling and assessment.

The permit writer should begin evaluating the application with examination of the trial burn plan. The elements and considerations that should be included in the trial burn plan are identified and discussed in Chapter 2. Guidance for evaluating the waste analysis plan and waste analysis data is also presented in Chapter 2. This evaluation includes designation of the principal organic hazardous constituents (POHCs) for each waste described in a permit application. Guidance is presented in Section 2.1 for making this designation.

Methods for evaluating incinerator performance data are presented in Chapter 3. Sample calculations of destruction and removal efficiency (DRE), scrubber efficiency, and correction of particular emissions are provided in

Chapter 3. Guidance for the specification of operating requirements is presented in Chapter 4 and examples of the development of specific permit conditions from incinerator performance data are included in Chapter 5.

Incinerator design information may be evaluated using the methods presented in the Engineering Handbook. The purpose of this evaluation is to ensure that the information is consistent with current engineering practice and that the unit may be expected to achieve compliance with the performance standards.

2.0 EVALUATION OF THE PERMIT APPLICATION

Evaluating the permit application encompasses four major activities:

- Evaluating the waste analysis procedures and information;
- Designating principal organic hazardous constituents (POHCs) for the waste feed;
- Reviewing and approving the trial burn plan and the proposed operating conditions;[1] and
- Evaluating the incinerator design.

This chapter provides guidance for evaluating the waste analysis plan and data, designating POHCs and evaluating the trial burn plan. Guidance for evaluating incinerator design is provided in the Engineering Handbook.

The guidance presented in this chapter will assist the permit writer in reviewing waste analysis data and the trial burn plan. This chapter discusses the chemical and physical analysis of wastes, stack gases and other incineration residues, use of contrived waste blends in the trial burn, and alternatives for planning the trial burn. Section 2.2 presents a method for selection of principal organic hazardous constituents (POHCs) from waste analysis data. The permit writer should recognize that this method has been selected as the best of several alternatives, after careful consideration of the advantages and disadvantages of each. The POHC selection method presented here may be used in most cases, although there may be instances where the permit writer will select some additional POHCs using other methods.

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[1] Operating conditions will often, but not always, be included in a trial burn plan. Review and approval of a trial burn plan prior to conducting the trial burn is required for new incinerators. For incinerators operating in interim status,it is strongly recommended, but not required, that a trial burn plan be submitted.

2.1 Evaluating The Waste Analysis Information

Waste analysis for the RCRA program is conducted at two levels of detail. A thorough waste analysis is required for initial characterization, providing sufficient data for the permit writer to evaluate Part B permit applications, trial burn plans, and permit modifications. Information regarding routine variations in waste composition should be included in the initial characterization. This information is used to establish permit conditions. During on-going operational periods the applicant may analyze wastes less extensively in order to ensure compliance with the permit conditions and to detect manifest discrepancies during routine incincerator operation. The analytical parameters for routine analysis are suggested by the applicant, evaluated by the permit writer, and included in the waste analysis plan, which is a part of the permit.

The permit application should identify the procedures used for sampling and analyzing the waste feed[2], the incinerator stack gas, and incineration residues (e.g., bottom ash, scrubber solutions, and other residues from air pollution control devices). Sampling and analysis methods that are not standard EPA procedures should be described in detail. All sample preparation and storage techniques should be described. Detection limits and standard calibrations should be provided for each analytical method used.

The Agency has recommended sampling techniques and analytical methods for waste analysis in its document Test Methods for Evaluating Solid Waste: Physical/Chemical Methods (SW-846, Second Edition, July 1982). Methods for sampling and analysis of stack gases and other incineration residues are provided in the EPA document , Sampling and Analysis Methods for Hazardous Waste Combustion (Arthur D. Little, Inc., February 1983). The methods proposed in the trial burn plan should be taken from those described in these two documents. The incineration manual, however, provides only general methods for sampling and analysis, and modifications to these methods should be made, if necessary, to ensure that 99.99% destruction and removal efficiency can be verified. Such modificatons would include, for example, increased sample collection times or modifications to the elements of the sampling train.

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[2] The term "waste feed" is used here to indicate the waste stream as it enters the incinerator. This feed may be a blend of "wastes" received from several different generators or production processes.

Some applicants may propose the use of analytical methods different from those recommended by EPA. In all such cases, detailed descriptions of the analytical protocols should be provided. The permit writer must evaluate the proposed analytical methods in order to determine whether they are equivalent to those recommended by EPA. This evaluation should include consideration of factors such as detection limits, precision, accuracy, and potential interferences.

2.1.1 Analysis for POHC Selection

In order to establish compliance with te performance standards for 99.99% destruction and removal of organic waste constituents, the regulations provide for selection, by the permit writer, of principal organic hazardous constituents (POHCs) for each waste feed to be burned. POHCs are hazardous organic constituents of the waste, selected from the list of hazardous constituents in 40 CFR Part 261, Appendix VIII, that are representative of those constituents most difficult to burn and most abundant in the waste. During the trial burn, the destruction and removal efficiency is actually measured only for the POHCs and the incinerator's performance in treating these substances is used to indicate overall performance in combusting organic waste. This aspect of the incinerator standards simplifies the sampling and analysis efforts which are necessary to determine whether the performance standard has been achieved, thereby reducing the cost and complexity of the trial burn.

To facilitate selection of POHCs and measurement of DRE, the applicant must provide the permit writer with detailed waste analysis information. The sampling and analysis manual describes a 3-step procedure for generating the necessary analytical information in an efficient manner without requiring rigorous quantitative analysis for hundreds of organic compounds. This procedure, which employs a reverse search technique, reduces the complexity and cost of waste feed analysis because the analysis is directed at those specific compounds that are expected to be present in the waste.

In the first step of the procedure, the applicant should establish a list of hazardous constituents, from among those listed in 40 CFR Part 261, Appendix VIII, that are reasonably expected to be present in the waste feed. These selections should be based on the applicant's knowledge of the waste normally fed to the incinerator and the industrial processes from which the wastes are generated.[3] Once the list of "expected" hazardous constituents is completed, the applicant should generate a chromatogram from a sample of the waste feed using the mass spectrometer techniques presented in SW-846.

In the second step of the procedure, the applicant should conduct a computerized reverse search of the chromatogram to identify and quantify any of the "expected" constituents detected in the chromatogram. At this stage, quantification of each constituent will not be highly accurate. The concentation generated, however, will generally be sufficient for selection of POHCs by the permit writer, and should be included in the trial burn plan. Procedures for conducting the reverse search are provided in SW-846.

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[3] The trial burn plan must also identify any constituents from Appendix VIII that are excluded from the analysis and provide the rationale for the exclusions.

The third step in the data collection process takes place at the time of the trial step in the data collection process takes place at the time of the trial burn and should be addressed in the trial burn plan. It is during this step that the data needed to accurately calculate the incinerator's destruction and removal efficiency are generated. Using the methods provided in SW-846, the applicant should analyze the waste feed and the stack gas in order to quantify POHC levels present in each, to the prescribed detection limits.

In order to maintain accuracy in the DRE calculation, waste feed should be sampled periodically during the trial burn. In general, waste feed samples should be collected simultaneously with stack gas samples. For example, the trial burn plan may specify taking a 3-hour stack sample for each set of operating conditions to be tested. During the 3-hour stack sampling period, the waste feed could be sampled at 15-minute intervals and the samples composited over the 3-hour period. In this manner, accuracy is maintained without requiring analysis of very large numbers of waste feed samples.

2.1.2 Analysis For Other Waste Characteristics

In addition to identification and quantification of hazardous constituents, the incinerator standards require the applicant to measure the viscosity (where appropriate) and heating value of the waste feed. Viscosity measurements provide the permit writer with information necessary to judge the adequacy of liquid waste delivery systems. The heating value of the waste feed is needed to determine and maintain adequate operating conditions and may be used to establish permit conditions.

The standards also allow the Regional Administrator to request any information, in addition to that specifically required, that is needed to evaluate incinerator performance and establish adequate operating conditions. Rationales for the selection of additional waste parameters are summarized in

Table 2-1. The ash content of the waste feed should be determined in order to specify permit conditions for allowable variations in waste feed. Measurement of ash content also allows evaluation of potential for slag and particulate formation. If the waste is solid or sludge, a thermogravimetric analysis (measurement of weight loss as a function of temperature) provides valuable information. Knowledge of flash point or explosivity helps to ensure safe handling of the wastes. Measurement of carbon, hydrogen, sulfur, nitrogen, phosphorous and oxygen concentrations and the water content of the waste feed is needed to compute stoichiometric air requirements and evaluate proposed excess air usage. Measurement of organically bound chloride content is necessary to evaluate potential emissions of gaseous hydrogen chloride and to establish permit conditions for allowable variations in waste content. Analytical methods for measurement of these parameters are provided in Table 2-2.

2.1.3 Analysis Required To Support Exemption

Applicants proposing to burn hazardous wastes that are ignitable, corrosive, or reactive may qualify for exemption from most of the standards for incineration, including the performance standards (40 CFR 264.343), requirements for continuous monitoring (40 CFR 264.347), inspection requirements (40 CFR 264.347), and limitations on incinerator operating conditions. Eligibility for the exemption is determined on the basis of waste composition. Therefore, after completion of the second step in the waste analyis procedure, the applicant may decide to apply for the exemption. If so, the permit application will include the waste analysis plan and data but will not include a trial burn plan. The permit writer must evaluate the waste analysis information and determine whether an exemption should be granted.

TABLE 2-1

RATIONALE FOR SELECTION OF WASTE ANALYSIS PARAMETERS

Parameters	Rationle
PCB Content	Incineration of wastes containing more than 50 ppm PCB is regulated under 40 CFR 761.60.
Organically Bound Chloride Content	The organically bound chloride content is used to compute the hydrogen chloride removal efficiency and to estimate uncontrolled hydrogen chloride emissions.
Ash Content Solids Content	The ash content of a waste may be determined to evaluate potential slag formation, to assess particulate removal requirements of an air pollution control system, and to determine if the ash handling capability of the system is sufficient.
Flash Point Explosivity	Knowledge of these values helps to enusre safe handling of a waste. Explosive wastes must be detonated in accordance with the restrictions imposed under 40 CFR 265.382.
Carbon, Hydrogen, Sulfur, Nitrogen, Phosphorous, Oxygen, Water Content	Knowledge of the concentraton of these substances is necessary if stoichiometric air requirements are computed to correlate oxygen concentrations in the stack gas with excess air usage.
Thermogravimetric Analysis	Thermogravimetric analysis helps to characterize wastes by reducing weight loss as a function of temperature.
Cyanide and Sulfide	Hazardous wastes exhibiting the reactivity characteristic and containing cyanides or sulfides are not exempt from compliance with the Subpart O requirements.

TABLE 2-2
ACCEPTABLE ANALYTICAL METHODS FOR WASTE ANALYSIS

Parameter	Method(s)*	Comments
Heating Value	SA A006	Methods D2015 and D3826 are applicable to solid wastes and D240 is applicabe to liquid wastes.
Chlorine (Organically bound)	SA A004 ASTM D2361, E442	Combuston method, may be combined with determination of carbon, hydrogen and sulfur.
Hazardous Metals:	SA A021	Summary of atomic absorption and ICAP methods.
Mercury	SW 7470, 7471	These methods are based on detection of mercury vapor by atomic absorption spectrophotometer, and are subject to interferences. Spiked samples should be analyzed to establish recovery. Methods involving strong oxidation, such as ASTM D3223, should be avoided because of the possibility of explosions. Alternatively, atomic absorption may be used with a graphite furnace.
Arsenic Selenium	SW 7060, 7061 SW 7740, 7741	Gaseous hydride generation coupled with atomic absorption detection is recommended. This method is subject to interferences so spiked samples should be anlayzed to establish recovery. Colorimetric methods, such as EPA 206.4 or ASTM D3081, should not be used because of interferences. Alternatively, atomic absorption may be used with a graphite furnace.
Barium Beryllium Cadmium Chromium Nickel Thallium Lead Silver Antimony	SW 7080, 7081, EPA 208.1 SW 7090, 7091, EPA 210.1 SW 7130, 7131, EPA 213.1 SW 7190, 7191, 7195, 7196, 7197 EPA 218.1 SW 7520, 7521, EPA 249.1 SW 7840, 7841, EPA 279.1 SW 7420, 7421, EPA 239.1 SW 7760, 7761, EPA 272.1 SW 7040, 7041, EPA 204.1	These methods are for direct aspiration, flame, atomic absorption spectroscopy. Sample preparation should be performed in accordance with Section 200.1 of the EPA manual. Generally, the sensitivy achieved with the graphite furnace techniques is not required with hazardous waste samples, and the furnace methods are subject to interferences.
Hazardous Constituents, including PCB	Sampling and Analysis Manual	Hazardous constituents listed in Appendix VIII of Part 261 and those in Table 1 of 261.24 may be analyzed by methods in SW-846.
Kinematic Viscosity	SA A005 ASTM D445 or D88	A variety of methods may be employed using various types instruments, including rational, piston, float, vibrating probe or capillary types.
Percent Solids	ASTM D1888	A distinction should be noted between water insoluble solids and solids not soluble in organic solvents. Any of a variety of separation techniques may be employed; vacuum filtration, centrifugation, pressure filtration, etc.
Sulfur	ASTM D3177, E443	Combustion methods.
Ash	SA A001-A002 ASTM D3174 or D482	D3174 is for solid wastes and D482 is for liquid wastes.
Flash Point	ASTM D93, D3278, or D1310	Methods D93 and D3278 are pursuant to the definition of ignitable wastes in Section 261.21 of the regulations D1310 provides comparable results.
Carbon and Hydrogen	ASTM D3178	Combustion method.
Moisture	SA A001-A002 ASTM D95, D3173	D95 is a xylene co-distillation and is recommended for most wastes. D3173 and A001-A002 are intended for solid wastes, but the oven heating will drive off volatile compounds in addition to water. D1796 is a centrifuge method intended for use with liquids.

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* SA refers to Sampling and Analysis Manual for Hazardous Waste Incineration, First Edition
SW refers to Test Methods for Evaluating Solid Waste, SW-846, Second Edition
ASTM refers to American Society for Testing and Materials Standards
EPA refers to Chemical Analysis of Water and Wastes, EPA 600/4-79-020

The exemption is available to incinerators burning wastes that are ignitable, corrosive, or that have any of the reactivity characteristics listed in 40 CFR 261.23(a)(1), (2), (3), (6), (7), and (8). The applicant must also demonstrate that the waste contains only insignificant concentrations of Appendix VIII constituents. The regulation provides for automatic granting of the exemption to facilities burning ignitable, corrosive or reactive wastes that have been shown to contain none of the hazardous constituents listed in Appendix VIII of 40 CFR Part 261 that would reasonably be expected to be present. In addition, ignitable, corrosive, and reactive wastes having low concentrations of some Appendix VIII constituents may be exempted if the Regional Administrator finds that the exemption will not result in a potential threat to human health and the environment. Wastes eligible for the exemption include those that are hazardous solely due to any one of the selected characteristics and those that are hazardous solely due to any combination of those characteristics. Wastes listed as hazardous in 40 CFR Part 261 due to the presence of toxic constituents, wastes having the extraction procedure toxicity characteristics (40 CFR Part 261, Appendix II), and wastes containing significant concentrations of Appendix VIII constituents are not eligible for exemption.

The first step in determining whether exemption is appropriate should be verification that the waste or wastes have only those hazardous characteristics allowed by the regulation: ignitability, corrosivity, or certain of the reactivity characteristics. If the waste has been specifically listed as a hazardous waste by EPA (40 CFR Part 261, Subpart D), the applicant should verify that the Agency's basis for listing the waste as hazardous did not include toxicity or the reactivity characteristics of 40 CFR 261.23(a)(4) or (5). Physical/Chemical Methods (SW-846) provides analytical methods for determining whether the waste has the reactivity characteristics of 40 CFR 261.23(a)(4) and (5).[4]

The second step in the decision process requires review of the waste analysis information to verify that the waste contains only insignificant (if any) levels of Appendix VIII constituents. This step should involve examination of the sampling and analytical methods. The methods required for collecting representative samples are listed in the regulations (40 CFR Part 261, Appendix I) and are discussed, in detail, in SW-846. The permit writer should refer to SW-846 and determine whether the applicant has used appropriate sampling techniques.

Analysis of the waste for hazardous constituents should be conducted as described previously. The applicant need analyze only for those constituents reasonably expected to be present, and should identify those Appendix VIII constituents not reasonably expected and provide a brief rationale for excluding them from the analysis. The analysis should be conducted using the methods presented in SW-846. If the analysis shows that none of the expected constituents were present in concentrations sufficient to be detected by the SW-846 analytical methods, the exemption should be granted.

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[4] 40 CFR 261.23(a)(4) describes reactive wastes that, when mixed with water, generate toxic gases, vapors, or fumes in sufficient quantity to present a danger to human health and the environment. 40 CFR 261.23(a)(5) describes sulfide or cyanide bearing wastes that when exposed to pH conditions between 2 and 12.5 can generate toxic gases, vapors, or fumes in sufficient quantity to present a danger to human health and the environment.

In the majority of cases, however, several hazardous constituents will be detected at low levels and the permit writer will need to determine whether they can be considered "insignificant". Since a waste feed concentration of 100 parts per million (ppm) represents a practical lower limit below which detection in the stack gas will be difficult, the permit writer may use 100 ppm as a standard against which an initial determination of "significant" or "insignificant" can be made for most toxic compounds. The exemption probably should not be allowed if any of the Appendix VIII hazardous constituents are present in concentrations of 100 ppm or greater.

In some cases, the permit writer may find it necessary to deny the exemption even if hazardous constituents are present in concentrations lower than 100 ppm. This may occur, for example, if the constituent is known to be highly toxic. In such cases, provisions should be made during the trial burn to ensure that verification of 99.99% destruction and removal efficiency is possible. The trial burn waste may be spiked with pure chemical in order to increase the concentration of a POHC present at less than 100 ppm. Alternatively, the volume of the stack gas sample collected may be increased to ensure that the POHC will be detected during analysis.

The sample stack gas volume necessary to verify 99.99% destruction and removal efficiency may be estimated according to the following procedure.

The quantity of waste (in pounds) needed to generate sufficient quantity of POHC in the stack gas sample can be calculated from the formula:

$$W = \frac{Q \times 10^4}{454(C)}$$

where: W = Quantity of waste (lbs) to generate $Q \times 10^4$ ug of POHC in stack gas sample;

C = Concentration of POHC in waste feed (ug/g = ppm); and

Q = Quantity of POHC (ug) needed in the stack gas sample to ensure detection.

Assuming that 1 standard cubic foot (SCF) of combustion gas is generated for every 100 Btu burned at stochiometric conditions, and given the heating value of the waste and the amount of air fed to the combustion chamber in excess of stoichiometric requirements, the dry volume of the stack gas sample, at standard temperature and pressure (68°F or 20°C and 29.92 in H_g) can be estimated from the formula:

$$V_S = (W \times H_W \times A)/100$$

where: V_S = Dry volume of the stack gas sample at standard temperature and pressure (dscf):

H_W = Heating value of the waste (Btu/lb); and

A = $\dfrac{\text{Air feed to combustion chamber}}{\text{Stoichiometric Air Requirement}}$

This volume must be corrected to the coresponding volume at stack conditions and corrected to include the volume of gas generated by burning auxiliary fuel, as follows:

$$V_D = ((460 + T)/528 \times (((H_F \times R \times W)/100) + V_S)$$

where: V_D = Actual dry volume of stack gas sample (corrected to stack temperature and for contribution from auxiliary fuel) (dacf);

T = Stack gas temperature (°F);

H_F = Heating value of fuel (Btu/lb) and

R = $\dfrac{\text{Fuel Feed Rate}}{\text{Waste Feed Rate}}$

°R = °F + 460°F

The dry sample volume must then be corrected to account for water vapor in the stack gas. After passing through an air pollution control system, the stack will likely be saturated with water. Figure 2-1 shows the water content of saturated stack gas as a function of quenched stack gas temperature. The corrected sample volume is calculated from the formula:

$$V_W = V_D/(1-K)$$

where: V_W = Volume of the stack gas sample including water vapor; and

K = Concentration (volume fraction) of water in the flue gas (% volume of water/100).

If the flue gas is not quenched, the water content of the flue gas depends on the waste feed and must be taken into account on a case by case basis.

The utility of this calculation is illustrated by the following example. A waste feed having the characteristics:

C = Concentration of hexachlorobenzene = 400 ppm

H_W = Waste heating value = 6500 Btu per pound,

will be burned under the following condiitions:

T = Stack gas temperature = 160°

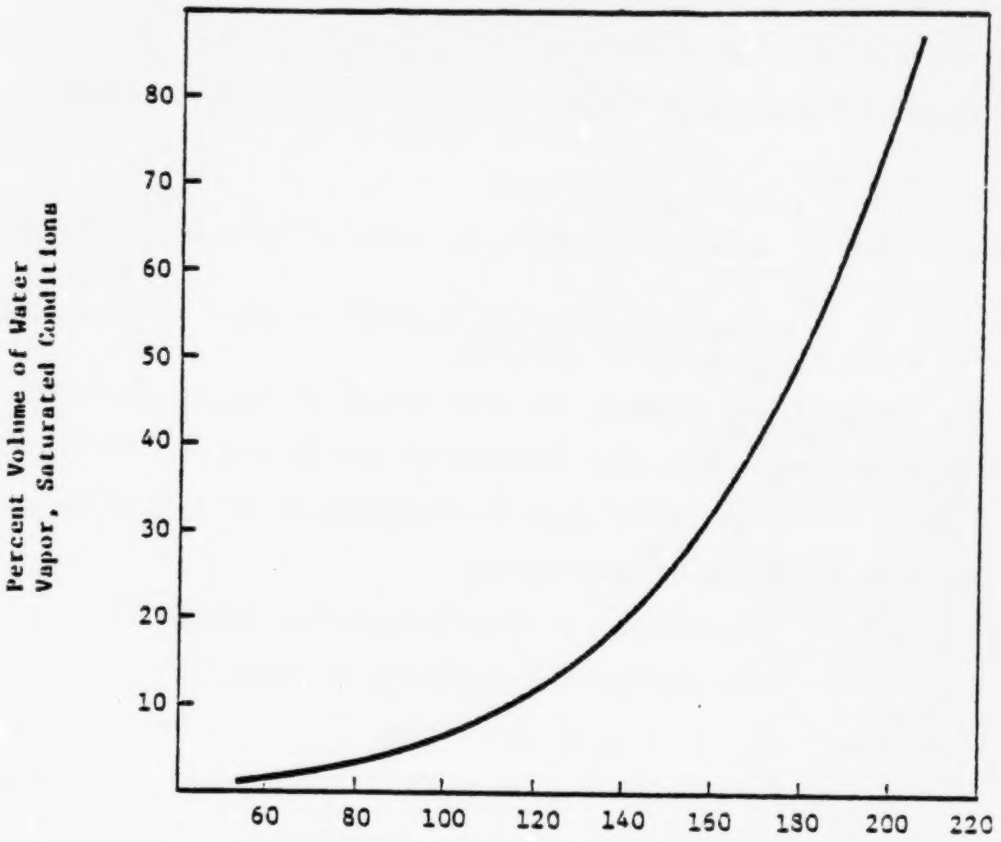
$A = \dfrac{\text{Air fed to the combustion chamber}}{\text{Stoichiometric air requirement}} = 1.2$

$R = \dfrac{\text{Fuel feed rate}}{\text{Waste feed rate}} = .20$

The auxiliary fuel used has a heating value of 19,000 Btu per pound (H_f) and the flue gas is saturated with water. A quantity of 10 ug of hexachlorobenzene is necessary in the stack gas sample to ensure detection. Therefore, the waste burned to generate 10 ug of HCB in the stack gas, at 99.99% DRE, must contain 1×10^5 ug of HCB, and

FIGURE 2-1

WATER VAPOR CONTENT OF SATURATED FLUE GAS



Gas Temperature, °F

Basis: Volume of water vapor in saturated air at 1 atm.

$V_s = ((10^5/(454 \times 400)) \times 6500 \times 1.2)/100$

$= 42.9$ dscf

$V_D = ((460 + 160)/528) \times (((19{,}000 \times 0.20 \times 0.55)/100) + 4.29)$

$= 74.9$ dacf

$K = 0.32$ from Figure 2-1, therefore:

$$V_W = \frac{74.9}{1 - 0.32}$$

$= 110$ acf

Thus, a minimum of 110 acf of stack gas should be collected to ensure detection of hexachlorobenzene to 99.99% DRE.

2.2 Designating Principal Organic Hazardous Constituents

In accordance with the incinerator regulations, the permit writer must designate one or more of the organic hazardous constituents identified in the waste feed as principal organic hazardous constituents (POHCs). The regulation specifies that POHC selection be based on a consideration of two factors: the degree of incinerability and the concentration of each organic hazardous constituent in the waste feed. EPA has therefore developed a method, presented here for systematic consideration of these two factors in selecting POHCs.

The method presented uses the heat of combustion of the hazardous constituent as an indication of incinerability. Constituents having low heat of combustion values are assumed to be less able to support combustion. Table 2-3 lists in alphabetical order the organic hazardous constituents from 40 CFR Part 261, Appendix VIII, and provides the heat of combustion (kilocalories per gram) of each. These same constituents are ranked in Table 2-4, according to ease of incinerability (i.e., those most difficult to

TABLE 2-3
HEAT OF COMBUSTION OF ORGANIC HAZARDOUS CONSTITUENTS FROM APPENDIX VIII, PART 261

Hazardous Constituent	H_c/MW kcal/gram
Acetonitrile	7.37
Acetophenone	8.26
3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts (Warfarin)	7.00*
2-Acetylaminofluorene	7.92*
Acetyl chloride	2.77*
1-Acetyl-2-thiourea	4.55*
Acrolein	6.95
Acrylamide	5.75*
Acrylonitrile	7.93
Aflatoxins	5.73*
Aldrin	3.75*
Allyl alcohol	7.75
4-Aminobiphenyl	9.00
6-Amino-1,1a,2,8,8a,8b-hexahydro-8-(hydroxymethyl)8a-methoxy 5-methylcarbamate azirino (2',3':3,4)pyrrolo(1,2-a)indole-4,7-dione (ester)(Mitomycin C)	5.41*
5-(Aminomethyl)-3-isoxazolol	4.78
4-Aminopyridine	7.37*
Amitrole	4.01*
Aniline	8.73
Auramine	7.69*
Azaserine	3.21*
Benz(c)acridine	8.92*
Benz(a)anthracene	9.39
Benzene	10.03
Benzenearsonic acid	3.40*
Benzenethiol	8.43
Benzidine	9.18
Benzo(b)fluoranthene	9.25
Benzo(j)fluoranthene	9.25
Benzo(a)pyrene	9.25
Benzoquinone	6.07
Benzotrichloride	3.90*
Benzyl chloride	6.18
Bis(2-chloroethoxy)methane	4.60*
Bis(2-chloroethyl)ether	3.38*
N,N-Bis(2-chloroethyl)-2-naphthylamine	6.64*
Bis(2-chloroisopropyl)ether	4.93*
Bis(chloromethyl)ether	1.97*
Bis(2-ethylhexyl)phthalate	8.42*
Bromoacetone	2.66*
Bromomethane	1.70*
4-Bromophenyl phenyl ether	5.84*
Brucine	7.42
2-Butanone peroxide	6.96*
Butyl benzyl phthalate	8.29*
2-sec-Butyl-4,6-dinitrophenol (DNBP)	5.46*
Chloral(Trichloroacetaldehyde)	0.80*
Chlorambucil	5.93*
Chlordane	2.71*
Chlorinated benzenes, N.O.S.	N/A
Chlorinated ethane, N.O.S.	N/A
Chlorinated fluorocarbons	N/A
Chlorinated naphthalene, N.O.S.	N/A
Chlorinated phenol, N.O.S.	N/A
Chloroacetaldehyde	2.92*
Chloroalkyl ethers	N/A
p-Chloroaniline	6.14*
Chlorobenzene	6.60
Chlorobenzilate	5.50*
p-Chloro-m-cresol	5.08*
1-Chloro-2,3-epoxybutane	5.19*

TABLE 2-3 (Continued)

Hazardous Constituent	H_c/MW kcal/gram	Hazardous Constituent	H_c/MW kcal/gram
2-Chloroethyl vinyl ether	5.19*	Dibenzo(a,h)pyrene	9.33*
Chloroform	.75	Dibenzo(a,i)pyrene	9.33*
Chloromethane	3.25	1,2-Dibromo-3-chloropropane	1.48*
Chloromethyl methyl ether	3.48*	1,2-Dibromoethane	1.43*
2-Chloronaphthalene	7.37	Dibromomethane	0.50*
2-Chlorophenol	6.89	Di-n-butyl phthalate	7.34*
1-(o-Chlorophenyl)thiourea	5.30*	Dichlorobenzene, N.O.S.	4.57
3-Chloropropionitrile	4.50*	3,3'-Dichlorobenzidine	5.72*
Chrysene	9.37	1,4-Dichloro -2-butene	4.27*
Citrus Red No. 2	--	Dichlorodifluoromethane	0.22*
Coal tars	N/A	1,1-Dichloroethane	3.00
Creosote	N/A	1,2-Dichloroethane	3.00
Cresol	8.18	trans-1,2-Dichloroethene	3.00
Cresylic Acid	8.09*	Dichloroethylene, N.O.S.	2.70
Crotonaldehyde	7.73	1,1-Dichloroethylene	2.70
Cyanogen	6.79	Dichloromethane	1.70
Cyanogen bromide	.81*	Dichloromethylbenzene	5.09*
Cyanogen chloride	1.29*	2,4-Dichlorophenol	3.81*
Cycasin	3.92*	2,6-Dichlorophenol	3.81*
2-Cyclohexyl-4,6-dinitrophenol	5.74*	Dichloropropane	3.99
Cyclophosphamide	3.97*	Dichlorophenylarsine	2.31*
Daunomycin	5.70*	1,2-Dichloropropane	3.99
DDD	5.14*	Dichloropropanol, N.O.S.	2.84
DDE	5.05*	Dichloropropene, N.O.S.	3.44*
DDT	4.51*	1,3-Dichloropropene	3.44*
Diallate	5.62*	Dieldrin	5.56*
2,4-D	3.62*	Diepoxybutane	5.74
Dibenz(a,h)acridine	9.53*	Diethylarsine	5.25*
Dibenz(a,j)acridine	9.53*	1,2-Diethylhydrazine	8.68*
Dibenz(a,h)anthracene(Dibenzo(a,h)anthracene)	9.40*	Diethyl phthalate	6.39
7H-Dibenzo(c,g)carbazole	8.90*	Dihydrosafrole	7.66*
Dibenzo(a,e)pyrene	9.33*		

TABLE 2-3 (Continued)

Hazardous Constituent	H_c/MW kcal/gram
3,4-Dihydroxy-alpha-(methylamino)-methyl benzyl alcohol	6.05*
Dimethoate	4.02
3,3'-Dimethoxybenzidine	7.36*
p-Dimethylaminoazobenzene	6.97*
7,12-Dimethylbenz(a)anthracene	9.61
3,3'-Dimethylbenzidine	8.81*
Dimethylcarbamoyl chloride	5.08*
1,1-Dimethylhydrazine	7.87
1,2-Dimethylhdrazine	7.87
3,3-Dimethyl-1-(methylthio)-2-butanone-O-(methylamino)carbonyl oxime	5.82*
Dimethylnitrosoamine	5.14*
alpha,alpha-Dimethylphenethylamine	9.54*
2,4-Dimethylphenol	8.51
Dimethyl phthalate	5.74
Dimethyl sulfate	2.86
Dinitrobenzene, N.O.S.	4.15
4,6-Dinitro-o-cresol and salts	4.06*
2,4-Dinitrophenol	3.52
2,4-Dinitrotoluene	4.68
2,6-Dinitrotoluene di-n-octyl phthalate	6.67*
1,4-Dioxane	6.41
Diphenylamine	9.09
1,2-Diphenylhydrazine	8.73*
Di-n-propylnitrosamine	7.83*
Disulfoton	5.73*
2,4-Dithiobiuret	2.12*
Endosulfan	2.33*
Endrin	3.46*
Ethyl carbamate	4.73*
Ethylenebisdithiocarbamate	5.70*
Ethyl cyanide	4.57
Ethyleneimine	7.86*
Ethylene oxide	6.86
Ethylenethiourea	5.98*
Ethyl methacrylate	7.27*
Fluoranthene	9.35
2-Fluoroacetamide	3.24
Formaldehyde	4.47
Formic acid	1.32
Glycidylaldehyde	5.74
Halomethane, N.O.S.	N/A
Heptachlor	2.96*
Heptachlor epoxide	2.71*
Hexachlorobenzene	1.79
Hexachlorobutadiene	2.12*
Hexachlorocyclohexane (all isomers)	1.12*
Hexachlorocyclopentadiene	2.10*
Hexachloroethane	.46
1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo, endo-dimethanonaphthalene	3.38*
Hexachlorophene	3.82*
Hexachloropropene	0.70*
Hydrazine	4.44*
Indeno(1,2,3-c,d)pyrene	8.52*
Iodomethane	1.34
Isocyanic acid, methyl ester	4.69*
Isobutyl alcohol	8.62
Isosafrole	7.62
Kepone	2.15*
Lasiocarpine	--
Maleic anhydride	3.40

TABLE 2-3 (Continued)

Hazardous Constituent	H_c/MW kcal/gram	Hazardous Constituent	H_c/MW kcal/gram
Maleic hydrozide	4.10*	Nitroglycerine	3.79
Malononitrile	5.98	4-Nitrophenol	4.95
Melphalan	5.21*	4-Nitroquinoline-1-oxide	5.59
Methacrylonitrile	8.55*	5-Nitro-o-toluidine	5.98
Methanethiol	5.91*	Nitrosoamine, N.O.S.	N/A
Methapyrilene	7.93*	N-Nitrosodi-N-butylamine	8.46*
Methomyl	5.20*	N-Nitrosodiethanolamine	7.02*
Methoxychlor	5.59*	N-Nitrosodiethylamine	6.86*
2-Methylaziridine	9.09*	N-Nitrosodimethylamine	5.14*
3-Methylcholanthrene	9.57*	N-Nitroso-N-ethylurea	3.92*
4,4'-Methylene-bis-(2-chloroaniline)	4.84*	N-Nitrosomethylethylamine	6.13*
Methyl ethyl ketone (MEK)	8.07	N-Nitroso-N-methylurea	2.89*
Methyl hydrazine	6.78*	N-Nitroso-N-methylurethane	4.18*
2-Methyllactonitrile	6.43	N-Nitrosomethylvinylamine	7.91*
Methyl methacrylate	6.52*	N-Nitrosomopholine	5.22*
Methyl methanesulfonate	3.74	N-Nitrosonornicotine	7.07*
2-Methyl-2-(methylthio)propionaldehyde-o-(methylcarbonyl) oxime	5.34*	N-Nitrosopiperidine	7.04*
N-Methyl-N'-nitro-N-nitrosoguanidine	4.06*	N-Nitrosopyrrolidine	6.43*
Methylparathion	4.00*	N-Nitrososarcosine	3.19*
Methylthiouracil	4.79*	7-Oxabicyclo(2.2.1)heptane-2,3-dicarboxylic acid	4.70*
Mustard gas	4.06*	Paraldehyde	6.30*
Naphthalene	9.62	Parathion	3.61*
1,4-Naphthoquinone	6.97	Pentachlorobenzene	2.05*
1-Naphthylamine	8.54	Pentachloroethane	0.53*
2-Naphthylamine	8.54	Pentachloronitrobenzene(PCNB)	1.62*
1-Naphthyl-2-thiourea	7.50*	Pentachlorophenol	2.09
Nicotine and salts	8.92*	Phenacetin	7.17
p-Nitroaniline	5.50	Phenol	7.78
Nitrobenzene	5.50	Penylenediamine	7.81
Nitrogen mustard and hydrochloride salt	4.28*	Phenyl dichloroarsine	3.12*
Nitrogen mustard N-oxide and hydrochloride salt	3.56		

TABLE 2-3 (Cont'd)

Hazardous Constituent	H_c/MW kcal/gram
Phenylmercury acetate	2.71*
N-Phenylthiourea	6.93*
Phthalic acid esters, N.O.S.	N/A
Phthalic anhydride	5.29
2-Picoline	8.72
Polychlorinated biphenyl isomers	
Monochloro	7.75*
Dichloro	6.36*
Trichloro	5.10*
Tetrachloro	4.29*
Pentachloro	3.66*
Hexachloro	3.28*
Heptochloro	2.98*
Octachloro	2.72*
Nonachloro	2.50*
Decachloro	2.31*
Pronamide	5.72*
1,3-Propane sultone	3.67*
n-Propylamine	9.58
Propylthiouracil	6.28*
2-Propyn-1-ol	7.43*
Pyridine	7.83
Reserpine	6.70*
Resorcinol	6.19
Saccharin	4.49*
Safrole	7.68
Strychnine and salts	8.03
2,4,5-TP	5.58*
2,4,5-T	2.87*
1,2,4,5-Tetrachlorobenzene	2.61*
TCDD	3.43*
Tetrachloroethane, N.O.S.	1.39
1,1,1,2-Tetrachloroethane	1.39
1,1,2,2-Tetrachloroethane	1.39
Tetrachloroethene (Tetrachloroethylene)	1.19
Tetrachloromethane (Carbon tetrachloride)	0.24
2,3,4,6-Tetrachlorophenol	2.23*
Tetraethyl lead	4.04*
Tetranitromethane	0.41*
Thioacetamide	5.95*
Thiosemicarbazide	4.55
Thiourea	4.55
Thiuram	5.85*
Toluene	10.14
Toluene diamine	8.24*
o-Toluidine hydrochloride	6.63*
Toluene diisocyanate	5.92*
Toxaphene	2.50*
Tribromomethane	0.13
1,2,4-Trichlorobenzene	3.40*
1,1,1-Trichloroethane	1.99
1,1,2-Trichloroethane	1.99
Trichloroethene (Trichloroethylene)	1.74
Trichloromethanethiol	0.84*
Trichloromonofluoro methane	0.11*
2,4,5-Trichlorophenol	2.88*
2,4,6-Trichlorophenol	2.88*
Trichloropropane, N.O.S.	2.81

TABLE 2-3 (Continued)

Hazardous Constituent	H_c/MW kcal/gram
1,2,3-Trichloropropane	2.81
Trypan blue	3.84*
Uracil mustard	4.00*
Vinyl chloride	4.45*

*Computed by method of Handrick, Ind. Eng. Che., 48:1366 (1956).
N/A: Not applicable, see individual constituents.
Sources: Lange's Handbook of Chemistry, 11th Edition, McGraw-Hill, 1973
Cox and Pilcher, Thermochemistry of Organic and Organo-metallic Compounds, Academic Press, London, 1970.

TABLE 2-4

RANKING OF INCINERABILITY OF ORGANIC HAZARDOUS CONSTITUENTS FROM APPENDIX VIII, PART 261 ON THE BASIS OF HEAT OF COMBUSTION

Hazardous Constituent	Heat of Combustion kcal/gram	Hazardous Constituent	Heat of Combustion kcal/gram
Trichloromonofluoromethane	0.11	Bis (chloromethyl) ether	1.97
Tribromomethane	0.13	1,1,1-Trichloroethane	1.99
Dichlorodifluoromethane	0.22	1,1,2-Trichloroethane	1.99
Tetrachloromethane (Carbon tetrachloride)	0.24	Pentachlorobenzene	2.05
Tetranitromethane	0.41	Pentachlorophenol	2.09
Hexachloroethane	0.46	Hexachlorocyclopentadiene	2.10
Dibromomethane	0.50	Hexachlorobutadiene	2.12
Pentachloroethane	0.53	Kepone	2.15
Hexachloropropene	0.70	2,3,4,6-Tetrachlorophenol	2.23
Chloroform	0.75	Dichlorophenylarsine	2.31
Chloral(trichloroacetaldehyde)	0.80	Decachlorobiphenyl	2.31
Cyanogen bromide	0.81	Endosulfan	2.33
Trichloromethanethiol	0.84	Nonachlorobiphenyl	2.50
Hexachlorocyclohexane	1.12	Toxaphene	2.50
Tetrachloroethene (Tetrachloroethylene)	1.19	1,2,4,5-Tetrachlorobenzene	2.61
Cyanogen chloride	1.29	Bromoacetone	2.66
Formic acid	1.32	Dichloroethylene, N.O.S.	2.70
Iodomethane	1.34	1,1-Dichloroethylene	2.70
Tetrachloroethane, N.O.S.	1.39	Chlordane	2.71
1,1,1,2-Tetrachloroethane	1.39	Heptachlor epoxide	2.71
1,1,2,2-Tetrachloroethane	1.39	Phenylmercury acetate	2.71
1,2-Dibromoethane	1.43	Octachlorobiphenyl	2.72
1,2-Dibromo-3-chloropropane	1.48	Acetyl chloride	2.77
Pentachloronitrobenzene	1.62	Trichloropropane, N.O.S.	2.81
Bromomethane	1.70	1,2,3-Trichloropropane	2.81
Dichloromethane	1.70	Dichloropropanol, N.O.S.	2.84
Trichloroethene (Trichloroethylene)	1.74	Dimethyl sulfate	2.86
Hexachlorobenzene	1.79	2,4,5-T	2.87

TABLE 2-4 (Continued)

Hazardous Constituent	Heat of Combustion kcal/gram
2,4,5-Trichlorophenol	2.88
2,4,6-Trichlorophenol	2.88
N-Nitroso-N-methylurea	2.89
Heptachlorobiphenyl	2.98
1,1-Dichloroethane	3.00
1,2-Dichloroethane	3.00
trans-1,2-Dichloroethane	3.00
Phenyl dichloroarsine	3.12
N-Nitrososarcosine	3.19
Azaserine	3.21
2-Fluoroacetamide	3.24
Chloromethane	3.25
Hexachlorobiphenyl	3.28
Bis (2-chloroethyl) ether	3.38
1,2,3,4,10,10-Hexachloro-1,4,4a,5,7,8a-hexahydro-1,4:5,8-endo, endo-dimethanonaphthalene	3.38
Benzenearsonic acid	3.40
Maleic anhydride	3.40
1,2,4-Trichlorobenzene	3.40
TCDD	3.43
Dichloropropene, N.O.S.	3.44
1,3-Dichloropropene	3.44
Endrin	3.46
Chloromethyl methyl ether	3.48
2,4-Dinitrophenol	3.52
Nitrogen mustard N-oxide and hydrochloride salt	3.56
Parathion	3.61
2,4-D	3.62
Pentachlorobiphenyl	3.66
1,3-Propane sultone	3.67
Methyl methanesulfonate	3.74
Aldrin	3.75
Nitroglycerine	3.79
2,4-Dichlorophenol	3.81
2,6-Dichlorophenol	3.81
Hexachlorophene	3.82
Trypan blue	3.84
Benzotrichloride	3.90
Cycasin	3.92
N-Nitroso-N-ethylurea	3.92
Cyclophosphamide	3.97
Dichloropropane, N.O.S.	3.99
1,2-Dichloropropane	3.99
Methylparathion	4.00
Uracil mustard	4.00
Amitrole	4.01
Dimethoate	4.02
Tetraethyl lead	4.04
4,6-Dinitro-o-cresol and salts	4.06
N-Methyl-N -nitro-N-nitrosoguanidine	4.06
Mustard gas	4.06
Maleic hydrazide	4.10
Dinitrobenzene, N.O.S.	4.15
N-Nitroso-N-methylurethane	4.18
1,4-Dichloro-2-butene	4.27
Nitrogen mustard and hydrochloride salt	4.28
Tetrachlorobiphenyl	4.29

TABLE 2-4 (Continued)

Hazardous Constituent	Heat of Combustion kcal/gram	Hazardous Constituent	Heat of Combustion kcal/gram
Hydrazine	4.44	Phthalic anhydride	5.29
Vinyl chloride	4.45	1-(o-chlorophenyl) thiourea	5.30
Formaldehyde	4.47	2-Methyl-2-(methylthio) propionaldehyde-o-(methylcarbonyl) oxime	5.34
Saccharin	4.49	2-sec-Butyl-4,6 dinitrophenol (DNBP)	5.46
3-Chloropropionitrile	4.50	p-Nitroaniline	5.50
DDT	4.51	Chlorobenzilate	5.50
Thiourea	4.51	Dieldrin	5.56
1-Acetyl-2-thiourea	4.55	2,4,5-TP	5.58
Thiosemicarbazide	4.55	Methoxychlor	5.59
Dichlorobenzene, N.O.S.	4.57	4-Nitroquinoline-1-oxide	5.59
Ethyl cyanide	4.57	Diallate	5.62
Bis (2-chloroethoxy) methane	4.60	Daunomycin	5.70
2,4-Dinitrotoluene	4.68	Ethylenebisdithiocarbamate	5.70
Isocyanic acid, methyl ester	4.69	3,3'-Dichlorobenzidine	5.72
7-Oxabicyclo (2.2.1) heptane-2,3-dicarboxylic acid	4.70	Pronamide	5.72
Ethyl carbamate	4.73	Aflatoxins	5.73
5-(Aminomethyl)-3-isoxazolol	4.78	Disulfoton	5.73
Methylthiouracil	4.79	4,6-Dinitrophenol	5.74
4,4'-Methylene-bis-(2-chloroaniline)	4.84	Diepoxybutane	5.74
Bis (2-chloroisopropyl) ether	4.93	Dimethyl phthalate	5.74
4-Nitrophenol	4.95	Glycidylaldehyde	5.74
DDE	5.05	Acrylamide	5.75
Dimethylcarbamoyl chloride	5.08	3,3-Dimethyl-1-(methylthio)-2-butanone-O-(methylamino)carbonyl oxime	5.82
p-Chloro-m-cresol	5.08	4-Bromophenyl phenyl ether	5.84
Dichloromethylbenzene	5.09	Thiuram	5.85
Trichlorobiphenyl	5.10	Methanethiol	5.91
DDD	5.14	Tolylene diisocyanate	5.92
Dimethylnitrosoamine	5.14	Chlorambucil	5.93
N-Nitrosodimethylamine	5.14	Thioacetamide	5.95
Diethylarsine	5.25		

TABLE 2-4 (Continued)

Hazardous Constituent	Heat of Combustion kcal/gram	Hazardous Constituent	Heat of Combustion kcal/gram
Ethylenethiourea	5.98	2-Butanone peroxide	6.96
Malononitrile	5.98	p-Dimethylaminoazobenzene	6.97
5-Nitro-o-toluidine	5.98	1,4-Naphthoquinone	6.97
Nitrobenzene	6.01	3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts (Warfarin)	7.00
3,4-Dihydroxy-alpha-(methylamino)methyl benzyl alcohol	6.05	N-Nitrosodiethanolamine	7.02
Benzoquinone	6.07	N-Nitrosopiperidine	7.04
N-Nitrosomethylethylamine	6.13	N-Nitrosonornicotine	7.07
p-Chloroaniline	6.14	Phenacetin	7.17
Benzyl chloride	6.18	Ethyl methacrylate	7.27
Resorcinol	6.19	Di-n-butyl phthalate	7.34
Propylthiouracil	6.28	3,3'-Dimethoxybenzidine	7.36
Paraldehyde	6.30	Acetonitrile	7.37
Dichlorobiphenyl	6.36	4-Aminopyridine	7.37
Diethyl phthalate	6.39	2-Chloronaphthalene	7.37
Dioxane	6.41	2 Propyn-1-ol	7.43
2-Methyllactonitrile	6.43	1-Naphthyl-2-thiourea	7.50
N-Nitrosopyrrolidone	6.43	Isosafrole	7.62
Methyl methacrylate	6.52	Dihydrosafrole	7.66
Chlorobenzene	6.60	Safrole	7.68
o-Toluidine hydrochloride	6.63	Auramine	7.69
N,N-Bis (2-chloroethyl)-2-naphthylamine	6.64	Crotonaldehyde	7.73
2,6-Dinitrotoluene di-n-octyl phthalate	6.67	Allyl alcohol	7.75
Reserpine	6.70	Monochlorobiphenyl	7.75
Methyl hydrazine	6.78	Phenol	7.78
Cyanogen	6.79	Phenylenediamine	7.81
Ethylene oxide	6.86	Di-n-propylnitrosoamine	7.83
N-Nitrosodiethylamine	6.86	Pyridine	7.83
2-Chlorophenol	6.89	Ethyleneimine	7.86
N-Phenylthiourea	6.93	1,1-Dimethylhydrazine	7.87
Acrolein	6.96	1,2-Dimethylhydrazine	7.87

TABLE 2-4 (Continued)

Hazardous Constituent	Heat of Combustion kcal/gram
N-Nitrosomethylvinylamine	7.91
2-Acetylaminofluorine	7.82
Acrylonitrile	7.93
Methapyrilene	7.93
Strychnine and salts	8.03
Methyl ethyl ketone (MEK)	8.07
Cresylic acid	8.09
Cresol	8.18
Toluene diamine	8.24
Acetophenone	8.26
Butyl benzyl phthalate	8.29
Ethyl cyanide	8.32
Bis (2-ethylhexyl) phthalate	8.42
Benzenethiol	8.43
N-Nitrosodi-N-butylamine	8.46
2,4-Dimethylphenol	8.51
Indenol (1,2,3-c,d) pyrene	8.52
Diethylstilbestrol	8.54
1-Naphthylamine	8.54
2-Naphthylamine	8.54
Methacrylonitrile	8.55
Isobutyl alcohol	8.62
1,2-Diethylhydrazine	8.68
2-Picoline	8.72
Aniline	8.73
1,2-Diphenylhydrazine	8.73
3,3'-Dimethoxybenzidine	8.81
7H-Dibenzo (c,g) carbazole	8.90
Benz (c) acridine	8.92
Nicotine and salts	8.92
4-Amino biphenyl	9.00
Diphenylamine	9.09
2-Methylaziridine	9.09
Benzidine	9.18
Benzo (b) fluoranthene	9.25
Benzo (j) fluoranthene	9.25
Benzo (a) pyrene	9.25
Dibenzo (a,e) pyrene	9.33
Dibenzo (a,h) pyrene	9.33
Dibenzo (a,i) pyrene	9.33
Fluoranthene	9.35
Benz (a) anthracene	9.39
Dibenz (a,h) anthracene (Dibenzo (a,h) anthracene)	9.40
Dibenz (a,h) acridine	9.53
Dibenz (a,j) acirdine	9.53
alpha, alpha-Dimethylphenethylamine	9.54
3-Methylcholanthrene	9.57
n-Propylamine	9.58
7,12-Dimethylbenz (a) anthracene	9.61
Naphthalene	9.62
Benzene	10.03
Toluene	10.14

incinerate, as indicated by their low heat of combustion values, are listed first).[5]

To select POHCs for a given waste feed, the permit writer should array the hazardous constituents and their concentrations in order of increasing incinerability (i.e., the order in which they appear on Table 2-4). The least incinerable constituent (i.e., that constituent having the lowest heat of combustion value) and the most abundant constituent should be designated as POHCs. In theory, only one POHC need be designated on the basis of incinerability. The correlation between heat of combustion and incinerability, however, is approximate. Therefore, more than one POHC should be designated on the basis of incinerability in most cases, particularly when the heat of combustion values indicate only small differences in incinerability. Overall, POHC selection should be limited to no more than six constituents.

Several methods have been proposed to measure incinerability. Among the parameters that have been suggested for developing a hierarchy are the autoignition temperature of the hazardous constituents, chemical kinetic rate constants for oxidation reactions, and the heats of combustion of the constituents. Applicants may use other parameters to establish a hierarchy. Rather than deciding whether an applicant's method of ranking incinerability is valid, which may not possible due to the limited amount of data available, the permit writer may require that several POHCs be selected from among two or more of the incinerability ranking systems. This approach provides the best test of incinerator performance and minimizes the errors present in any POHC ranking system. The applicant should include all data used to make POHC selections if the heat of combustion hierarchy is not used.

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[5] The correlation between incinerability and heat of combustion is an approximation. As EPA accumulates data regarding incinerability, the hierarchy (Table 2-4) will be adjusted to reflect actual observations.

The permit writer should also consider the limitations of stack gas sampling and analytical techniques when selecting POHCs. Constituents present in the waste feed in concentrations as low as 1,000 parts per million (ppm) should be routinely detected in the stack gas. A waste concentration of 100 ppm represents a practical lower limit below which determination of 99.99% destruction and removal efficiency will be difficult to document.

Whenever possible, POHC selection should be confined to constituents present in concentrations greater than 100 ppm. In cases where this is not possible, modification of the stack sampling and analytical methods may be necessary and the permit writer should determine that the methods described in the trial burn plan will be adequate. In cases where a POHC is selected that subsequently is not detected in the stack gas, despite careful fulfillment of the sampling, analysis and quality control procedures set out in the trial burn plan, attainment of DRE to the level of detectibility should be assumed.

When the trial burn plan proposes using a waste that contains one or more of the POHCs in low concentrations, the permit writer should estimate the volume of the stack gas sample necessary to detect the POHC present in low concentrations according to the method presented in Section 2.1.3. Once this estimate is made, the permit writer can evaluate the adequacy of the proposed sampling and analytical methods and recommend modifications, as necessary.

The following examples demonstrate application of the POHC selection criteria:

EXAMPLE 1

HAZARDOUS CONSTITUENT	% CONCENTRATION	HEAT OF COMBUSTION
Chloroform	3	.75
Dichloroethane	14	3.00
Dichlorobenzene	8	4.57
Chlorophenol	12	6.89

Using the POHC values, chloroform should be designated a POHC. Because the method is an approximation, there is probably no difference in the incinerability of the other three constituents. At least one of the other constituents should be designated a POHC in case a 99.99% DRE is not achieved for chloroform or because of possible errors in the ranking system.

EXAMPLE 2

HAZARDOUS CONSTITUENT	% CONCENTRATION	HEAT OF COMBUSTION
Chlorobenzene	6	6.60
Phenol	4	7.78
Benzene	4	10.03
Toluene	25	10.14

Using this method, toluene should be designated a POHC because it is present in the waste at a high concentration, even though it is relatively easy to incinerate. It is recommended that chlorobenzene be designated as an additional POHC in order to demonstrate that the least incinerable organic hazardous constituent is destroyed. In this example, the use of POHC value is inconclusive and other data may be used to select POHCs.

EXAMPLE 3

HAZARDOUS CONSTITUENT	% CONCENTRATION	HEAT OF COMBUSTION
Tetrachloromethane (Carbon/etrachloride)	.001	.24
Chloromethane	8	3.25
Dichloropropene	8	3.44

Using this method, tetrachloromethane should be designated a POHC. However, because it is present in the waste in such low concentration, there may be some difficulty in stack monitoring for this species. Either dichloropropene, chloromethane, or both should also be designated as POHCs to ease sampling and analysis problems.

2.3 Review Of The Trial Burn Plan

The trial burn is essentially a test to determine whether an incinerator is capable of meeting the performance standards and, if it does, to identify the operating conditions necessary to ensure that the performance standards will be met. The results of the trial burn directly influence the decision to issue a permit and the conditions of the permit. Careful and detailed planning of the trial burn is therefore necessary.

In its final form the trial burn plan should represent the interests of both the applicant and the permit writer. The data and information generated during the trial burn should be sufficient to allow the permit writer to establish permit conditions that provide enough latitude for the facility operator to accomodate some reasonable variations in waste composition and incinerator operating conditions. The facility operator may use the trial burn to identify a *range* of operating conditions within which the incinerator can achieve the required level of performance, thus allowing the operator the opportunity to optimize the incinerator operation within the required level of performance.

Table 2-5 lists the information required to be included in the trial burn plan. The table may be used as a checklist for purposes of determinng whether the applicant has included the minimum amount of information in the trial burn plan. This completeness check should always be the first step in reviewing the trial burn plan. Because the permit application for a new incinerator must be filed and a permit issued before construction begins, some of the information, such as waste composition data, may need to be updated before the trial burn is conducted. Similarly, specific analytical methods used in the trial burn may need to be updated or dates and schedules for the trial burn may require revision. Permit conditions should provide sufficient flexibility to allow such changes. A careful description of the expected variations will reduce the need for future major permit modifications requiring new public hearings.

2.4 Evaluating The Design Of The Trial Burn

In designing the trial burn, the primary goal of both the applicant and the permit writer should be to identify the conditions under which the incinerator must be operated in order to successfully treat the designated principal organic hazardous constituents. The waste fed to the incinerator and the operating conditions tested, therefore, are critical components of the trial burn plan. Because the results of the trial burn directly influence the conditions of the final operating permit and because modification of the final permit can be costly and time consuming, the waste

TABLE 2-5

CHECKLIST FOR CONTENT OF TRIAL BURN PLANS

Waste Analysis Data

Heating value of the waste

Viscosity (if applicable)

Concentrations of hazardous constituents listed in 40 CFR 261, Appendix VIII expected to be present in the waste

Organically bound chlorine content (recommended but not required)

Ash content (recommended but not required)

Incinerator Design Information

Manufacturer's name and model number of major incinerator components

Type of incinerator (rotary kiln, liquid injection, etc.)

Linear dimensions of major incinerator components and cross sectional area of the combustion chamber(s)

Description of auxiliary fuel system

Capacities of prime movers

Description of automatic waste feed cutoff system(s)

Stack gas monitoring and pollution control monitoring systems

Nozzle and burner design

Construction materials

Location and description of temperature, pressure and flow indicating and control devices

TABLE 2-5 (Continued)

Provisions for Sampling and Monitoring of the Incineration Process

Description of process monitoring equipment, procedures, and locations for:

- Combustion zone temperature
- Waste and fuel feed rates
- Combustion gas velocity
- Carbon monoxide in stack gas
- Oxygen in the stack gas

Computation of DRE, including methods for sampling and analysis of:

- POHCs in the stack gas,
- Stack gas volume flow rate and temperature
- Waste feed rate and POHC concentrations in waste feed

Determination of particulate emissions, including methods for measuring:

- Particulates
- Volume flow rate of stack gas
- Temperature of stack gas
- Water content of stack gas
- Oxygen concentration in stack gas
- Metals

Determination of scrubber efficiency including sampling and monitoring of stack gas for hydrochloric acid if emissions are greater than 4 pounds per hour

Trial burn Schedule

Dates of trial burn

Duration of trial burn

Quantity of waste feed to be burned

TABLE 2-5 (Concluded)

Trial Burn Protocol

Planned operating conditions for each performance burn including:

- Combustion zone temperature
- Waste feed rate
- Combustion gas velocity
- Use of auxiliary fuel and feed rate
- Carbon monoxide level in the stack gas

Planned operating conditions for air pollution control devices

Procedures for stopping waste feed, shutting down the incinerator, and controlling emissions in the event of an equipment malfunction or other emergency

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feed and operating conditions tested should be selected on the basis of a careful consideration of many facility-specific factors.

The applicant should attempt to account for any planned or possible changes in the waste feed when designing the trial burn. By selecting additional POHCs (particularly those that are known to be difficult to incinerate) or testing a wide range of operating conditions, the applicant may build sufficient flexibility into the final permit conditions to account for future changes in waste feed. In this manner, careful planning of the trial burn can reduce or even eliminate the need for further permit modifications and trial burns.

2.4.1 Selecting The Trial Burn Waste Feed

The specification of waste composition in a permit is developed primarily from the values of three parameters, specifically, the heating value of the waste, the organically bound chloride content, and the ash content. Other parameters may be used as agreed upon by the permit writer and the applicant. Relying on the three primary parameters, the applicant has several options to ensure tha the permit covers most of the wastes that will be incinerated at the facility.

The trial burn waste feed may take one of three forms: (1) the applicant may choose to burn the actual waste, or a mixture of actual wastes, normally accepted for treatment at the incinerator, (2) the applicant might choose to add hazardous constituents to the actual waste feed or may increase the concentration of constituents already present in the waste feed, (3) and the applicant may create an artificial waste feed by feeding a mixture of chemicals to the incinerator. The chemicals included in such a "waste" feed should be those that are selected as POHCs on the basis of waste analysis data.

Burning actual waste during the trial burn has the advantages of using materials that are readily available and providing data that are descriptive of normal operation. One option is to group wastes with similar characteristics and to demonstrate that each waste mix can be incinerated at specific operating conditions. The utility of this approach is best illustrated by a simplified example. An off-site liquid injection incinerator operator receives chlorinated solvents from eight generators and non-chlorinated solvents from four generators. Rather than conduct trial burns on each of 12 different wastes, the applicant may wish to group the chlorinated and the non-chlorinated wastes separately, and conduct a trial burn using the two waste mixes. In order to achieve the greatest benefit from waste grouping, the applicant should conduct a trial burn at the least incinerable composition, specifically, at the lowest heating value and the highest ash and chloride contents of each waste mix.

Using actual waste in the trial burn also has several disadvantages. Chemical analysis of both the waste and the stack gas may be complicated due to interference by waste constituents other than the POHCs. Most importantly, when actual waste is used, the applicant is restricted to testing only the hazardous constituents present in the waste. The permit, therefore, will allow burning of only those constituents more easily incinerated than the most difficult to incinerate constituent in the waste. If, after the permit is issued, the operator receives a waste containing a less incinerable constituent, an additional trial burn and major modification of the permit will be necessary.

Spiking the waste with less incinerable hazardous constituents provides the advantage of increasing the number of hazardous constituents that can be allowed by the permit. The permit writer should assume that if an incinerator can achieve a 99.99% DRE of a hazardous constituent, then it is also capable of achieving a 99.99% DRE of more easily incinerated constituents, if the same operating conditions are maintained. For example, it the applicant spikes the waste with chloroform or tribromomethane and 99.99% DRE is achieved, the permit may be written to allow burning of nearly all of the Appendix VIII hazardous constituents. Spiking the waste to increase the concentration of constituents already present will increase stack gas concentrations and reduce sampling and analytical difficulties. Generally, spiking the actual waste for use in the trial burn allows the applicant to compensate for the disadvantages of using actual waste and can be done without causing significant changes in characteristics such as physical state of the waste and particulate load.

Alternatively, the applicant may propose to incinerate a blend of chemicals and fossil fuel during the trial burn instead of actual waste. This approach is useful for new incinerators, particularly when waste will not be available at the time of the trial burn. When an artificial waste feed is used, the feed should be blended to contain the POHCs in concentrations equal to or greater than those expected during routine operation.

Using an artificial waste feed has the advantage of simplifying the analytical procedures because interference by organics other than the POHCs is greatly reduced. This approach also allows the applicant to create waste feed that is very difficult to burn. A successful trial burn conducted with such a waste feed results in permit conditions allowing the operator to accept a wide variety of wastes for treatment, perhaps eliminating any future need for permit modifications and additional trial burns. Operators of off-site commercial incinerators will generally need such latitude in the permit in order that they not be restricted in their ability to accept new clients. Use of wholly artificial waste feeds for the trial burn need not be restricted to new incinerators or cases where actual waste will not be available.

Conducting the trial burn with an artificial waste feed may add complexity to the trial burn plan. The artificial feed may be dissimilar to actual waste feed in physical state, heating value, chloride content, or ash content. When an artificial waste feed is used, data must be generated to document compliance with both the hydrogen chloride removal standard and the standard for control of particulate emissions. A variety of materials may be used to test compliance with the particulate emission standard. The advantages and disadvantages of the use of a limited number of materials are listed in Table 2-6. If available, incinerator fly ash should be used. Sand should not be used as a substitute for ash because it forms a slag layer in the combustion zone and contributes very little to flue gas particulate load. Ash from combustion of coal acts similarly because of its high silica content (40-60%). Diatomaceous earth and powdered gypsum or limestone will be entrained in the flue gas because of their small particle

TABLE 2-6
ADVANTAGES AND DISADVANTAGES OF MATERIALS TO INCREASE WASTE ASH CONTENT

Material	Advantages	Disadvantages
Sand	Similar to ash of wastes with high silicate content Readily available	Routinely added to rotary kilns to form protective slag layer Contributes very little entrained particulates - forms slag Not representative of metallic oxide ash
Coal Combustion	Will contribute some entrained particulates Readily available	High silica content (40-60%) Added to rotary kilns to form protective slag layer Metallic oxides are primarily iron and aluminum
Diatomaceous Earth or Filter Aids	May be present in some hazardous wastes (filter cakes) Small particle sizes ensure entrainment in flue gas Will not form slag	Relatively expensive Chemical composition may not be representative of incinerator ash

TABLE 2-6 (Concluded)
ADVANTAGES AND DISADVANTAGES OF MATERIALS TO INCREASE WASTE ASH CONTENT

Material	Advantages	Disadvantages
Incinerator Fly Ash	Readily available	May have to be dewatered or dried
	Will be entrained in flue gas	
	Will not form slag	
	Chemical composition representative of waste ash	
Gypsum and Limstone	May be entrained in flue gas	Must be powdered (100 mesh)
	Will not form slag	Chemical compositon not representative of waste ash ($CaSO_4$ $2H_2O$ = gypsum, CaO = limestone)
		Not likely to be present in hazardous wastes

sizes. These materials will not form a slag in the combustion chamber, but are very different in chemical composition from incinerator fly ash.

Materials containing organically bound chloride may be added to an artificial waste feed in order to test the efficiency of the gas scrubbing equipment. Hydrogen chloride removal efficiencies generally increases as the hydrogen chloride content of the influent gas stream increase, until the scrubber capacity is exceeded. The applicant may attempt to establish the maximum organically bound chloride concentration in the waste that the device can effectively control.

2.4.2 Operating Conditions

The results of the trial burn are the permit writers' principal basis for setting the conditions of the operating permit. It is therefore necessary that the data and information collected during the trial burn provide an accurate description of incinerator performance and operation. The trial burn data should identify a range of values for each operating parameter required by the standards, specifically: carbon monoxide level in the stack gas, waste feed rate, total thermal input rate, combustion temperature, and combustion gas flow rate within which the incinerator achieves the performance standards. The trial burn data should provide an indication of the effect on performance, particularly the destruction and removal efficiency, that results from a change in one or more of the operating parameters. For facilities that burn several wastes or waste mixes specific operating conditions may be associated with specific waste feed compositions.

At facilities where wastes from many sources are blended to make up the incinerator feed, the applicant might propose to burn several different waste blends during the trial burn and establish permit conditions for burning each blend. For example, those wastes that contain hazardous constituents from the upper third of the incinerability hierarchy (Table 2-3) might constitute one blend, the most difficult to incinerate. Wastes of moderate incinerability may be blended into a second waste blend, and wastes that are relatively easy to incinerate could make up a third blend. Presumably, the applicant could use the trial burn to identify a set of operating conditions for each blend, to be established as permit conditions. The operator would therefore be required to operate at the most stringent conditions only when burning the least incinerable blend. Temperature and auxiliary fuel could then be cut back when more easily incinerated blends are fed.

Conducting this type of trial burn is advantageous to the applicant because the resulting permit conditions can be sufficiently flexible so as not to disrupt normal operating practices or significantly increase operating costs. The cost of conducting the trial burn, however, increases as the plan becomes more complex. Therefore, decisions regarding the range of operating conditions to be tested and the number of waste blends to be burned during the trial burn should be suggested by the applicant.

Determination of the residence time of the waste in the combustion zone is not specifically required by the incinerator standards. Instead, control over residence time is established indirectly through the requirement for monitoring and controlling combustion gas flow rate and temperature. When the incinerator design includes multiple waste feed locations and multiple combustion chambers, sufficient residence time can be ensured by specifying an allowable feed location for each waste feed. The effects of specifying allowable feed locations on the trial burn plan structure may be determined from the example presented in Section 4.1.2.

At a minimum, the trial burn plan should propose operation at one set of steady state[6] operating conditions. The plan should specify intended steady state values for each operating parameter: carbon monoxide level in the stack gas, waste feed rate, combustion temperature and combustion gas flow rate. Maintenance of steady state conditions is essential to obtaining meaningful trial burn results. The applicant should be encouraged to operate the incinerator at the maximum thermal input and waste feed rates during a trial burn in order to ensure the greatest flexibility in permitted operation.

If the applicant proposes to continuously incinerate one waste stream that does not vary significantly in composition (i.e., the organic hazardous constituents remain the same, although concentrations may vary slightly), a simple trial burn plan may provide all of the information necessary. If compliance with the performance standards is not achieved, however, the applicant will be required to conduct an additional trial burn. Furthermore, if compliance is shown at only one steady state, the resulting permit conditions will restrict operation to those conditions. Therefore, the applicant should consider testing performance at the most severe and most lenient expected operating conditions, and possibly at intermediate conditions as well. Such operation will allow identification of the greatest range of acceptable incinerator capabilities and operating flexibility.

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[6] Steady state occurs when the value of a measured parameter does not significantly change.

Testing a range of operating conditions will be particularly important when the incinerator is new and has not been previously evaluated. In cases where the incinerator has been in operation under interim status and the operator is reasonably certain that 99.99% destruction and removal efficiency will be achieved, the trial burn plan may propose to test only those conditions under which the incinerator is normally operated. The applicant, however, should view the trial burn as a opportunity to test various operating conditions and determine whether operating costs can be reduced (e.g., by reducing combustion temperature, increasing waste feed rate, or reducing use of auxiliary fuel) without decreasing the level of performance.

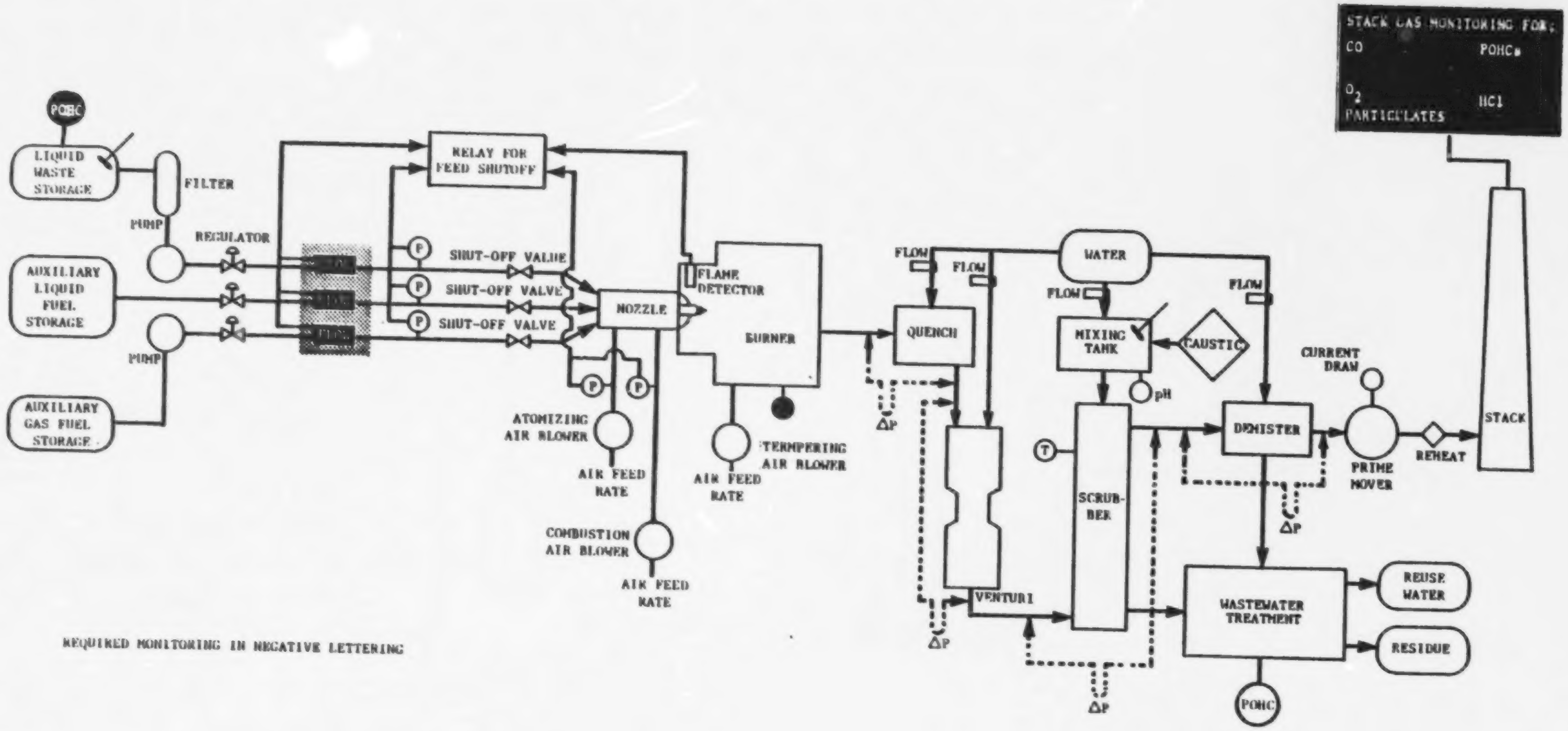
The permit writer's evaluation of the trial burn plan should focus on determining whether the applicant has provided all of the necessary information, whether the methods used for sampling and analysis are equivalent to those of SW-846, and whether the data generated are likely to establish that the incinerator is capabable of achieving the performance standards.

2.4.3 Provisions For Stack Gas Sampling And Monitoring

Comprehensive sampling and monitoring during the trial burn is essential for documenting compliance with the performance standards and for developing the conditions of the permit. At a minimum, sampling and monitoring data from the trial burn must be sufficient to provide for: a quantitative analysis of the POHCs in the waste feed to the incinerator; a quantitative analysis of the exhaust gas for the concentration and mass emissions of the POHCs, oxygen (O_2), and hydrogen chloride (HCl); a quantitative analysis of the scrubber water (if any), ash residues, and other residues for the POHCs; a computation of destruction and removal efficiency (DRE); a computation of HCl removal efficiency (if emissions exceed 1.8 kilograms per hour); a computation of particulate emissions; an identification of soures of fugitive emissions; a measurement of average, maximum, and minimum combustion temperature and gas velocity; and a continuous measurement of carbon monoxide in the exhaust gas (40 CFR 122.27(b)(vi)). When evaluating the trial burn plan, the permit writer should ensure that provisions for all required sampling and monitoring are included.

In addition to the sampling and monitoring specifically required, the permit writer should consider requesting that other parameters be measured. Combustion gas temperature at the point of entry to the air pollution control system may be routinely monitored by the applicant to ensure proper operation of the system. Flow rates for auxiliary fuel and scrubber liquid might also be monitored to further ensure that proper operating conditions are maintained.

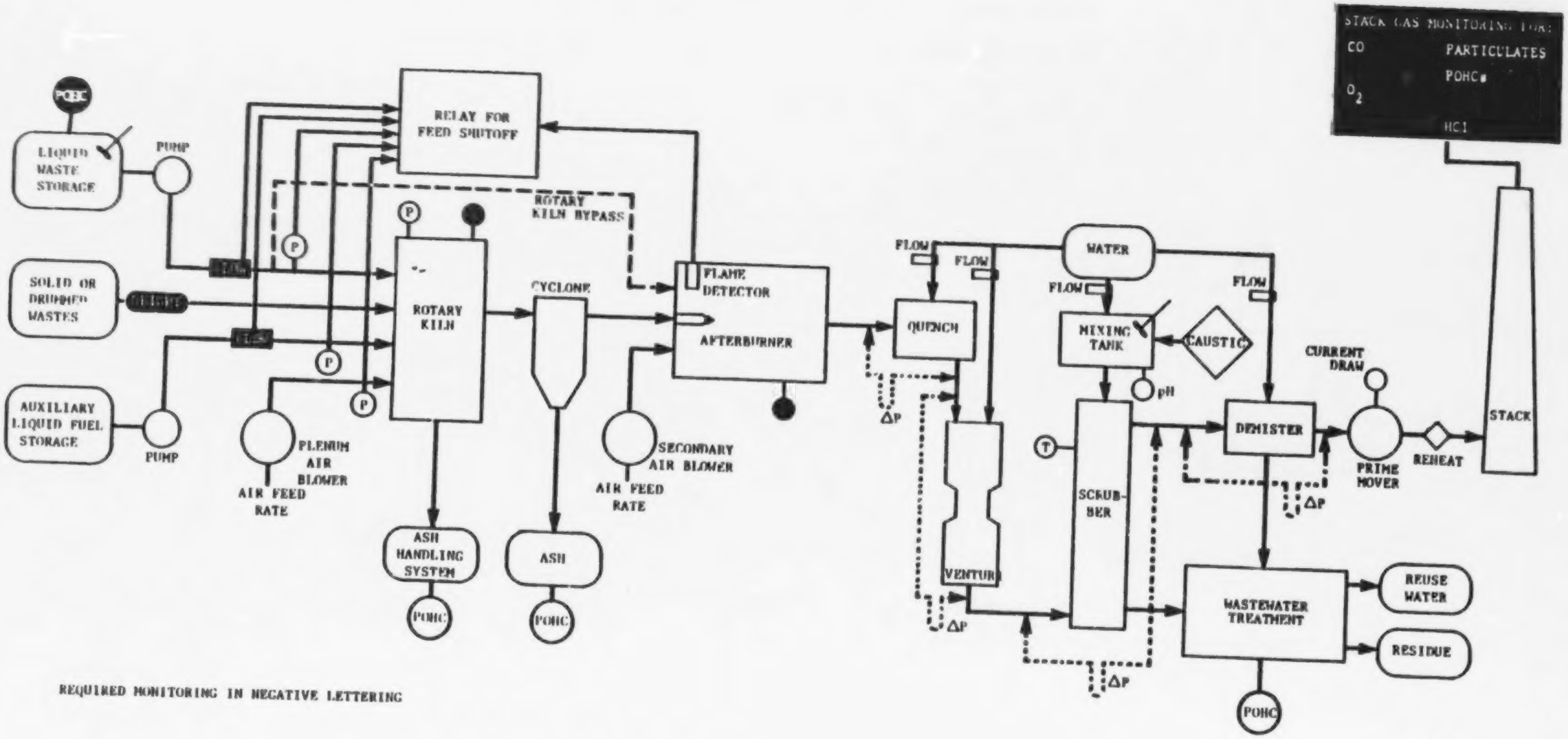
The trial burn plan should include descriptions of process monitoring equipment, sampling frequencies, and procedures. The location of each sampling and monitoring point should be indicated on the facility diagram. Typical sampling and monitoring locations are indicated in Figures 2-2 and 2-3, diagrams of a liquid injection incinerator and a rotary/kiln afterburner incinerator, respectively. Section 5.6 of the Engineering Handbook for Hazardous Waste Incineration (1) provides information concerning the use and capabilities of available monitoring devices.


STACK GAS MONITORING FOR:
CO
POHCs
O_2
HCl
PARTICULATES
POHC
LIQUID WASTE STORAGE
FILTER
PUMP
REGULATOR
AUXILIARY LIQUID FUEL STORAGE
PUMP
AUXILIARY GAS FUEL STORAGE
RELAY FOR FEED SHUTOFF
P
SHUT-OFF VALUE
SHUT-OFF VALVE
SHUT-OFF VALVE
NOZZLE
FLAME DETECTOR
BURNER
ATOMIZING AIR BLOWER
AIR FEED RATE
COMBUSTION AIR BLOWER
AIR FEED RATE
TEMPERING AIR BLOWER
AIR FEED RATE
FLOW
FLOW
QUENCH
ΔP
VENTURI
ΔP
WATER
FLOW
MIXING TANK
CAUSTIC
pH
T
SCRUB-BER
ΔP
FLOW
DEMISTER
ΔP
CURRENT DRAW
PRIME MOVER
REHEAT
STACK
WASTEWATER TREATMENT
POHC
REUSE WATER
RESIDUE

REQUIRED MONITORING IN NEGATIVE LETTERING

FIGURE 2-2

SCHEMATIC DIAGRAM SHOWING TRIAL BURN MONITORING LOCATIONS FOR A LIQUID INJECTION INCINERATOR


STACK GAS MONITORING FOR:
CO
PARTICULATES
POHCs
O_2
HCl
POHC
LIQUID WASTE STORAGE
PUMP
SOLID OR DRUMMED WASTES
AUXILIARY LIQUID FUEL STORAGE
PUMP
RELAY FOR FEED SHUTOFF
ROTARY KILN BYPASS
P
P
P
P
ROTARY KILN
PLENUM AIR BLOWER
AIR FEED RATE
ASH HANDLING SYSTEM
POHC
CYCLONE
ASH
POHC
FLAME DETECTOR
AFTERBURNER
SECONDARY AIR BLOWER
AIR FEED RATE
FLOW
FLOW
QUENCH
ΔP
VENTURI
ΔP
WATER
FLOW
MIXING TANK
CAUSTIC
pH
T
SCRUB-BER
ΔP
FLOW
DEMISTER
ΔP
CURRENT DRAW
PRIME MOVER
REHEAT
STACK
WASTEWATER TREATMENT
REUSE WATER
RESIDUE
POHC

REQUIRED MONITORING IN NEGATIVE LETTERING

FIGURE 2-3

SCHEMATIC DIAGRAM SHOWING TRIAL BURN MONITORING LOCATIONS FOR A ROTARY KILN INCINERATOR

3.0 EVALUATION OF INCINERATOR PERFORMANCE DATA

Compliance with the regulatory performance standards may be demonstrated using data obtained from trial burns, from incineration conducted during Interim Status, or from incineration conducted at a facility similar to the applicant's (see Chapter 1). Prior to evaluating data submitted in lieu of performing a trial burn, the permit writer must determine whether such data are applicable and similar to the incineration proposed in a permit application. Methods to determine the similarity of the previous and proposed incineration are presented in Section 3.1.

Permit applicants may provide many types of incineration performance data. There is no standard format for the submittal. Because permit conditions will be established from the data, the permit writer must be able to accurately interpret the information as provided by the applicant. Guidance for determination of the sufficiency of engineering data is provided in Section 3.2.

This chapter contains sample calculations for computation of destruction and removal efficiencies (DRE), particulate concentrations in the stack gas, and scrubber efficiencies to check compliance with the regulatory performance standards. Various factors affecting the calculations are identified in Sections 3.3, 3.4 and 3.5.

3.1 Evaluation of Data Submitted in Lieu of Trial Burn Results

When evaluating performance data submitted in lieu of trial burn results, the permit writer should make the following determinations:

- Similarity of previous and proposed wastes
- Similarity of previous and proposed incinerator units

These determinations should be made prior to checking the calculations of the incinerator performance results.

3.1.1 Similarity of Wastes

Prior to evaluating the waste analysis data submitted from previous incineration, the permit writer should ascertain that the waste previously incinerated is similar to the waste described in the permit application. If available data are so incomplete as to preclude comparison between the previous and proposed wastes, then the wastes should be considered dissimilar and performance data from the applicant's incinerator should be requested.

Suggested criteria for determination of waste similarity have been developed to ensure that the applicant's waste or mixture of wastes is as easily or more easily incinerated than the waste previously destroyed. In order for the proposed waste and the previously incinerated wastes to be considered similar, it is suggested that the criteria listed below be met.

- Heating Value - The heating value of the proposed waste must be equal to or higher than that of previously incinerated waste.
- Hazardous Constituents - The proposed waste must not contain any hazardous constituents considered more difficult to incinerate than those in the previously incinerated waste on the basis of the heat of combustion hierarchy. The use of other incinerability hierarchies is discussed elsewhere in this manual.
- Organic Chlorine Content - The organically bound chlorine content of the proposed waste must be equal to or lower than that of the previously incinerated waste.
- Ash Content - The ash content of the proposed waste must be equal to or lower than that of the previously incinerated waste.

Small increases in chloride and ash content may be allowed if the permitting official, in his best engineering judgement, finds that there is insignificant risk in not meeting the required standards. If all of these criteria are not satisfied, the wastes may not be similar and there is no basis for comparing the proposed and previous incineration. In cases of non-similarity, the permit writer should request the applicant to submit performance data from the incinerator for which a permit is sought.

3.1.2 Similarity of Incinerator Units

The incinerator unit design and operating data should enable the permit writer to compare the unit previously used to obtain operating data with the incinerator unit described in a permit application. It is, therefore, necessary that the data for the previous unit be as detailed as the data submitted for the proposed unit in order to determine similarity.

Criteria are presented in Table 3-1 for determining the similarity between the applicant's incinerator unit and the unit previously used for the incineration of a similar waste. If the previous incineration was conducted at the applicant's facility, and if the incinerator unit has not been modified, then this evaluation is not necessary. For the cases in which this evaluation is necessary, all the criteria in Table 3-1 should be satisfied for the units to be considered similar. The criteria are designed so that similarity means that the capabilities of an applicant's incinerator* to destroy a hazardous waste are nearly identical or superior to the capabilities of the incinerator previously used. If only some of the requirements are met, the units should be considered dissimilar and the permit writer should request the applicant to conduct a trial burn. A

TABLE 3-1

CRITERIA FOR DETERMINATION OF INCINERATOR SIMILARITY

Parameters	Criteria for Similarity	Rationale
Type	Proposed incinerator should be the same type as the previous incinerator	No method exists to correlate data from one type of incinerator with that of another type
Components and Dimensions	Proposed incinerator combustion zone volume and cross sectional area ±20% of the previous incinerator. Corresponding linear dimensions of major components should conform within ±10%	The effects of different incinerator geometrics on factors such as turbulence are difficult to quantify. It is assumed that similar performance may be expected from geometrically similar incinerators
Combustion zone temperature	Proposed incinerator should operate no less than 20°C below and no more than 200°C above the previous incinerator	Ensure same degree of destruction of hazardous constituents. Prevent failure of refractory structure
Residence time	Proposed incinerator should be no less than 5% below and no more than 100% above that of the previous incinerator	Prevent decreased mixing of combustibles in the proposed incinerator at 5% below that of the previous incinerator; at 100% above, the incinerator designs are not the same
Excess Air or ratio of air feed rate to waste feed rate	Proposed excess air should be equal to the previous incineration or no more than 50% greater. The ratio or air/waste feed rates should not differ by more than 10%	Maintain similarity in design performance, temperature and residence time for purposes of comparison
Air Pollution Control Devices (APCD)	Devices on the proposed incinerator should be of the same type (APCD Type as defined in Table D-2) as those on the previous incinerator. Liquid to gas ratios should be within ±20%	It is difficult to predict whether the same degree of performance will be obtained with different types of APCD
Auxiliary Fuel Use	Same auxiliary fuel should be used with ratios of waste/fuel feed rates not differing by more than 5%	Different fuels will interact differently with wastes during combustion. Different fuels require different air feed rates

detailed analysis of similarity could be complex and involve design and operation criteria which are not included in Table 3-1.

3.2 Interpretation of Engineering Data

The permit writer has two major purposes for interpreting engineering data, specifically to ensure that steady state conditions were achieved during the incinerator performance test and to determine the range of normal operating conditions. The permit writer must have the records of continuously monitored parameters in order to make these determinations. If an applicant specifies only average or median values of parameters monitored during a performance test, the permit writer should request the data from which the values were derived. Instead of presenting detailed methods for data evaluation in this manual, the permit writer may refer to the example of data interpretation presented in Chapter 5 and may seek technical assistance from available resources.

3.3 Calculation of Destruction and Removal Efficiency (DRE)

Incinerators burning hazardous waste must achieve a DRE of 99.99 percent for each principal organic hazardous constituent (POHC) in the waste feed as required under 40 CFR 264.343(a). The DRE is determined from the following equation:

$$\text{DRE} = ((W_{in} - W_{out})/W_{in}) \times 100$$

Where: W_{in} = Mass feed rate of the principal organic hazardous constituent (POHC) in the waste stream feeding the incinerator

W_{out} = Mass emission rate of the principal organic hazardous constituent (POHC) present in exhaust emissions prior to release to the atmosphere.

The waste feed rate is expressed in mass per unit time and must be consistent with the units used to express W_{out}. If a waste is co-fired with auxiliary fuel, the auxiliary fuel feed rate does not affect the calculation of W_{in}, unless the fuel contains the POHC.

W_{out} is calculated from stack sampling data and involves three steps:

- Computation of stack gas sample volume
- Computation of POHC concentration in stack sample
- Computation of stack gas volume flow rate

Stack gas sample volume and stack gas volume flow rate may be determined either by EPA Methods 2 and 5 in 40 CFR 60, or ASTM Method D2928(2). Monitoring stack emissions for POHCs includes sampling and analysis of particular matter, gas phase organics, and water present in the stack gas. Methods of stack sampling and laboratory analysis for POHCs are presented in the Sampling and Analysis Manual(3). Ideally, all sampling and analytical data should be included with a permit application. Table 3-2 identifies the necessary data and provides a method of computation allowing the permit writer to check the DRE calculated by an applicant. A sample calculation of DRE is presented in Table 3-3.

If the DRE in the example presented in Table 3-3 were 99.985%, it could not be rounded off to 99.99%. In developing this guidance manual, the EPA decided to restrict rounding for two reasons:

1. Rounding a DRE value of 99.985% to 99.99% would allow 50% more emission of a POHC than the standard would allow without any rounding. The example in Table 3-3 can be used to illustrate the point. The DRE of 99.9904% is obtained from a 133 lb/hr $waste_{in}$

TABLE 3-2

CALCULATION OF DRE

Step	Required Data	Computation
I. Computation of W_{in}	Designated POHC POHC concentration Waste feed rate	W_{in} = (Conc. of POHC)(Waste feed rate)
II. Computation of Stack Gas Sample Volume	V_m = Volume of gas measured by dry gas meter, corrected if necessary, dscf Y = Dry gas calibration factor P = Barometric pressure. in. Hg H = Average pressure differential across sampler orifice meter, in. H_2O T_m = Absolute average dry gas meter temperature, ^oR	$V_{m(std)} = K_1 V_m Y \frac{P + (H/13.6)}{T_m}$ where: $K_1 = 0.3858^oK/mm$ Hg $= 17.647^oR/in$ Hg
	Note: This sample volume must include water collected during sampling and be expressed under standard conditions (293°K, 760mm Hg; or 528°R, 29.92 in Hg). After the corrected dry gas volume has been computed, it must be corrected for the volume of water collected during sampling:	
	$V_{w(GAS)}$ = Volume of water vapor at standard conditions, scf	$V_{w(GAS)} = K_2 V_w$ where: $K_2 = 0.00133\ m^3/ml$ $= 0.0471\ ft^3/ml$
	V_w = Volume of water collected in impingers and silica gel, ml	

TABLE 3-2 (Continued)

Step	Required Data	Computation
	Note: The volume of water vapor is added to $V_{m(std)}$ to obtain sample volume:	Sample volume = $V_{w(GAS)} + V_{M(std)}$
III. Computation of POHC Concentration in Stack Sample (Cg)	Total weight of POHCs in the sample Volume of sample at standard conditions	$Cg = \frac{\text{Total weight of POHC in sample}}{\text{Volume of sample at standard conditions}}$
IV. Computation of Stack Gas Flow Rate	V_g = Gas velocity, ft/min. C = Pitot tube correction factor (usually 0.85 for Type S and 1.00 for others) P_s = Absolute pressure in flue, in. Hg G_s = Specific gravity of flue gas with respect to air: $G_s = M_s/(28.99)$ where: $M_s = M_d[(100-W)/100]+(0.18)(W)$ W = Water content of flue gas, % $M_d = (0.44)(\%CO_2)+(0.28)(\%CO)+(0.32)(\%O_2)+(0.28\%N_2)$ h = Velocity pressure at sampling point (if these differ greatly among the sampling points, the averages of the square roots of the velocity pressure must be used (see ASTM D2928) in. H_2O T_s = Absolute temperature of stack gas, ^oR	$Vg = 952C\sqrt{\frac{h\ Ts}{Ps\ Gs}}$

TABLE 3-2 (Concluded)

Step	Required Data	Computation
	Note: The stack gas flow rate is determined by a pitot tube which measures the difference between the total and static pressures in a flue. Gas velocity determinations are made at several locations during sampling and the values are averages. EPA Method 2 or ASTM Method 2928 may be used to obtain data.	
	Q = Stack gas volume flow rate at standard conditions, scf A_s = cross sectional area of stack, Ft^2	$Q = V_g A_s (528/T_s)(P_s/29.92)$
V. Computation of W_{out}	C_g = POHC concentration in stack gas Q = Stack gas volume flow rate at standard conditions	$W_{out} = C_g Q$
VI. Computation of DRE	W_{in} = waste in W_{out} = waste out	$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100$

TABLE 3-3

SAMPLE CALCULATION OF DRE

	Data	Computation
I.	Designated POHC: Hexachlorobenzene POHC Concentration: 13.3% Waste feed rate: 1000 lbs/hr	W_{in} = .133 (1000 lbs/hr) = 133 lbs/hr
II.	V_m = 31.153 dscf Y = 1.12 P = 29.82 in. Hg. H = .705 in. H_2O T_m = 554°R	$V_{m(std)} = 17.64 \frac{^oR}{in.\ Hg} (31.153\,dscf)(1.12) \left(\frac{29.82\ in.Hg + \frac{.705\ in.H20}{13.6}}{554^oR} \right)$ = 33.17 dscf
	V_w = 90.7 ml	V_w(Gas) = 0.0471(90.7) = 4.27 scf
	V_w(Gas) = 4.27 scf	Sample volume = 33.17 scf + 4.27 scf = 37.44 scf
	$V_{m(std)}$ = 33.17 scf	
III.	Total weight of POHC: 3.5 μg hexachlorobenzene extracted from water +12.3 μg hexachlorobenzene extracted from particulate matter +26.0 μg hexachlorobenzene extracted from gas phase trap	$Cg = \frac{4.18 \times 10^{-5}\ grams}{37.44\ scf}$ $= 1.116 \times 10^{-6}$ grams/scf $= 2.46 \times 10^{-9}$ lb/scf
	41.8 μg = 4.18×10^{-5} grams hexachlorobenzene	
	Sample volume = 37.44 scf [from Step II]	

TABLE 3-3 (Concluded)

	Data	Computation
IV.	$C = 0.85$ $P_s = 29.81$ in. Hg $G_s = 0.850$ $h = 0.202$ in. H_2O $T_s = 582\,^{\circ}R$	$Vg = 952(.85)\left(\frac{(.202)(582)}{(29.81)(0.850)}\right)^{0.5}$ $= 1743$ ft/min
	$A_s = 55.0\ ft^2$ $V_s = 1743$ ft/min (from first part of Step IV)	$Q = 1743$ ft/min $(55.0\ ft^2)(528/582)(29.81/29.92)$ $= 86{,}650$ scf/min
V.	$Cg = 2.46 \times 10^{-9}$ lb/scf [from Step III] $Q = 86{,}650$ scf/min	$W_{out} = 2.46 \times 10^{-9}$ lb/scf (86,650 scf/min)(60 min/hr) $= 0.0128$ lb/hr
VI.	$W_{in} = 133$ lbs/hr [from Step I] $W_{out} = 0.0128$ lbs/hr [from Step V]	$DRE = \frac{133\ lbs/hr - 0.0128\ lbs/hr}{133\ lbs/hr} \times 100$ $= 99.9904\%$

rate and a 0.0128 lb/hr $waste_{out}$ rate. If a DRE of 99.985% is used to solve for the allowable $waste_{out}$ with 133 lb/hr $waste_{in}$, a $waste_{out}$ value of 0.01995 lb/hr is obtained. A $waste_{out}$ rate of 0.01995 lb/hr is 156% of 0.0128 lb/hr. Thus the rounding allows over 50% more emissions than the 99.99% DRE.

2. Errors in sampling and analysis of POHCs in stack gases are compounded by rounding. Referring to the example above, if sampling and analysis results were in error by 50%, the actual emission rate of POHC would be 0.0299 lb/hr. Thus the potential error from rounding plus sampling and analysis errors becomes 133%. By restricting rounding of the DRE, magnification of sampling and analysis errors can be minimized. There may be limited circumstances where judgement could be used in rounding, e.g., where three or more POHCs have been selected and only one POHC has not achieved 99.99% DRE, rounding could be acceptable. However, if the failure is for the most-difficult-to-burn POHC, rounding is probably not appropriate. When used, rounding should be in accord with best engineering judgement and practice.

3.4 Hydrogen Chloride Emissions

An incinerator destroying hazardous waste and emitting more than 4 pounds per hour (1.8 kilograms per hour) of hydrogen chloride must be equipped with emission control equipment capable of removing 99 percent of hydrogen chloride from the exhaust gases or of limiting hydrogen chloride emissions to 4 pounds per hour, as required under 40 CFR 264.343(b). Waste and stack gas sample analyses usually are conducted for the chloride (Cl^-)

ions. The scrubber efficiency (SE) used to determine hydrogen chloride removal may be defined as follows, based on chloride analyses:

$$SE = ((Cl_{in} - Cl_{out})/Cl_{in}) \times 100$$

Where: Cl_{in} = mass feed rate of organically bound chlorides entering the incinerator

Cl_{out} = mass emission rate of hydrogen chloride in the scrubber exhaust gas prior to emission to the atmosphere

Where the term "scrubber efficiency" is used, the acid gas removal efficiency of the entire scrubber system, including the quench, particulate removal device, and gas absorber, is the parameter being considered. The efficiency of indivudal scrubber units can be determined, but a high efficiency for the total scrubber system is the fundamental desired parameter.

Since the gases exiting the scrubber are generally cool (180°F), sampling and analysis of this gas is comparatively easy and safe. Sampling of the hot incinerator exhaust gases is not simple and should be avoided. To avoid hot sampling, Cl_{in} may be calculated from the waste feed rate and the organically bound chlorine content of the feed. A method to compute scrubber efficiency is presented in Table 3-4 and a sample calculation of scrubber efficiency is presented in Table 3-5.

Cl_{out} is computed from stack monitoring data. Necessary data include:

- Volume of the stack gas sample at standard conditions
- Total chlorides (Cl^-) collected during sampling
- Stack gas volume flow rate at standard conditions

TABLE 3-4

CALCULATION OF SCRUBBER EFFICIENCY

Step	Required Data	Computation
I. Compute Cl_{in}	Concentration of chlorine in feed Waste feed rate	Cl_{in}=(Conc. of chlorine in feed) (Waste feed rate)
	Note: Chlorine content must be expressed as organically bound chloride (Cl^-), obtained from combustion methods of waste analysis.	
II. Compute Volume of Stack Gas Sample at Standard Conditions	Same as DRE calculation	See Table 3-2 for computation
III. Compute Total Chlorides in Stack Gas Sample	A = ml of titrant for sample N = Normality of mercuric nitrate titrant V_I = Volume of impinger solution V_S = Volume of sample aliquot	$\text{mg } Cl^- = \frac{35.45\ ANV_I}{V_S}$
IV. Compute Concentration of Chlorides (C_{Cl}) in the Stack Gas	$mgCl^-$ = total chlorides Gas sample volume [from Step II of the DRE computation]	C_{Cl} = mg Cl^-/sample volume
V. Compute Stack Gas Volume Flow Rate	Same as DRE calculation	See Table 3-2 for computation
VI. Compute CL_{out}	Q = Stack gas volume flow rate C_{Cl} = Concentration of Cl in stack gas	$Cl_{out} = Q(C_{Cl})$
VII. Compute Scrubber Efficiency Efficiency (SE)	Cl_{in} Cl_{out}	$SE = \frac{Cl_{in} - Cl_{out}}{Cl_{in}} \times 100$

TABLE 3-5

SAMPLE CALCULATION OF SCRUBBER EFFICIENCY

	Data	Computation
I.	$[Cl^-] = 25\%$ feed rate = 2000 lb/hr	$Cl_{in} = (.25)(2000\ \mathrm{lbs/hr})$ $= 500\ \mathrm{lbs/hr}$ $= 8.33\ \mathrm{lb/min}$
II.	V_m (std) See Table 3-3	33.17 dscf
III.	$A = 3.12$ ml $N = .01$ $V_I = 40$ ml $V_S = 10$ ml	$\mathrm{mg}\ Cl^- = \frac{35.45(3.12)(.01)(40)}{10}$ $= 4.43$ $= 9.74 \times 10^{-6}$ lb
IV.	$Cl^- = 9.74 \times 10^{-6}$ lb Sample Volume = 33.17 dscf	$C_{CL} = \frac{9.74 \times 10^{-6}\ \mathrm{lb}}{33.17\ \mathrm{dscf}}$ $= 2.94 \times 10^{-7}$ lb/scf
V.	See Table 3-3	86,650 scf/min
VI.	Q = 86,650 scf/min [from Step IV in Table 3-1] $C_{Cl} = 2.94 \times 10^{-7}$ lb/scf	Cl_{out} = (86,650 scf/min) x $(2.94 \times 10^{-7}$ lb/scf) = 0.0255 lb/min
VII.	Cl_{in} = 8.33 lb/min [Step I] Cl_{out} = 0.0255 lb/min [Step VI]	$SE = \frac{8.33\ \mathrm{lb/min} - 0.0255\ \mathrm{lb/min}}{8.33\ \mathrm{lb/min}} \times 100$ $= 99.69\%$

The method for computing the volume of the stack gas sample (V_m(std)) employed for the DRE calculation may be used to compute the scrubber efficiency.

The percentage of hydrogen chloride emitted in the stack gas, or scrubber efficiency, may not be rounded upwards. In the example presented in Table 3-5, if the scrubber efficiency was 98.81%, the value of Cl_{out} would be four times greater. The value of 98.81 percent may not be rounded off to 99 percent and is not in compliance with the regulatory performance standard.

If the scrubber efficiency is less than 99 percent when hydrogen chloride emissions are greater than 4 lb HCl/hr, the permit writer must notify the applicant that the hydrogen chloride emissions exceed the regulatory performance standard.

3.5 Particulate Emissions

Incinerators destroying hazardous wastes must not emit particulate matter at concentrations greater than 180 milligrams of particulates per dry standard cubic meter of stack gas (0.08 grains per dry standard cubic foot) when the stack gas is corrected to a 7 percent oxygen concentration, using the following formula for the correction factor specified in 40 CFR 264.343(c):

$$\text{Correction Factor} = 14/(21-Y)$$

Where: Y = measured oxygen concentration in the stack gas on a dry basis.

The measured particulate concentration is multiplied by the correction factor to obtain the corrected particulate emissions. A sample calculation of particulate matter concentration in the stack gas using the method referenced in the Sampling and Analysis Manual(3) is presented in Table 3-6.

TABLE 3-6

CALCULATION OF PARTICULATE EMISSIONS

Step	Required Data	Computation
I. Compute Stack Gas Sample Volume	Same as DRE calculation	See Step II on Table 3-2
II. Determine Particulates Weight	Stack sampling data, weight of collected particulates	Determined gravimetrically
III. Compute Particulate Matter Concentration(P)	Stack gas volume Particulate weight	P = (weight of collected particulate matter) ÷ (stack gas volume)
IV. Compute Correction Factor	Oxygen concentration in stack gas	$CF = \frac{14}{21-[O_2]}$
V. Correct the particulate concentration	P = Particulate matter CF = Correction factor Pc = Corrected particulate concentrations	Pc = P(CF)

The calculation involves the following steps:

- Determination of the stack gas sample volume
- Determination of weight of collected particulate matter
- Calculation of particulate concentration in the stack gas
- Determination of the oxygen concentration in the stack gas
- Correction of the measured particulate concentration

Particulate emission calculations are sensitive to the values of oxygen concentrations, and the permit writer may check that these values are obtained properly. If the oxygen concentration was found to be 10.0 percent instead of 8.0 percent in the sample calculation presented in Table 3-7, the particulate emissions would increase to 0.081 grains per dry standard cubic foot. Thus, the particulate emissions at 8.0 percent oxygen concentration are in compliance with the performance standard and the emissions at 10.0 percent oxygen concentration are not. Orsat analysis for the oxygen content of the flue gas is satisfactory and should be reported on a dry basis.

If the corrected particulate emissions are greater than 180 mg/dscm (0.08 gr/dscf), the permit writer must notify the applicant that particulate emissions exceed the regulatory performance standard.

TABLE 3-7

SAMPLE CALCULATION OF PARTICULATE EMISSIONS

	Data	Computation
I.	$V_{m(std)} = 33.17$ dscf	See Table 3-3
II.	Particulate weight = 137 milligrams (2.113 grains)	Gravimetric determination
III.	Particulate weight = 2.113 grains Stack gas volume = 33.17 dscf	$P = \frac{2.113 \text{ grains}}{33.17 \text{ dscf}}$ $= 0.0637$ gr/dscf
IV.	$[O_2] = 8.0\%$, dry basis	$CF = \frac{14}{21 - 8}$ $= 1.077$
V.	$P = 0.0637$ gr/dscf	$P_c = (0.0637)(1.077)$ $= 0.0686$ gr/dscf

4.0 SPECIFICATION OF PERMIT CONDITIONS

The permit writer must designate a set of operating requirements specific to each waste feed which the applicant indicates will be burned. These requirements must reflect the set of conditions which have been shown to achieve the performance standards of 40 CFR 264.343, either during a trial burn conducted in the unit for which the permit is sought, or by data submitted in lieu of conducting a trial burn. At a minimum, the permit must specify requirements for the carbon monoxide level in the stack gas, thermal input rate, combustion temperature, combustion gas flow rate, and acceptable variations in the waste feed composition (40 CFR 122.27(b)(vi)). In addition, the permit writer may include other operating requirement as necessary to ensure compliance with the performance standards. These may include, for example, conditions which may derive from trial burn results for specific combinations of wastes or alternate operating conditions to be used under specifically defined circumstances. Guidance for specifying each of these requirements is provided in Sections 4.1 and 4.2.

The permit must also include a schedule for conducting periodic facility inspections. Two types of inspections are required. The first, a visual inspection of the incinerator, must be conducted daily. The second type of inspection, testing of the emergency waste feed cut off system, should occur at weekly to monthly intervals. Guidance for determining the best means of testing the system and the frequency at which testing should occur is presented in Section 4.3.

Initially, the operating requirements for new incinerators will be established on the basis of the incinerator's anticipated performance capabilities. The requirements will be designated primarily on the basis of the design specifications provided with the permit application and experience or information gained from trial burns at other facilities. These requirements will then be modified when data from the trial burn is complete and evaluation of actual incinerator performance can occur. Further guidance regarding the specification of operating requirements from design data is presented in Section 4.4.

4.1 Specification of Operating Requirements From Performance Data

An incinerator permit must specify a set of operating requirements for the following parameters:

- Carbon monoxide level in the stack exhaust gas
- Waste feed rate
- Combustion temperature
- Combustion gas flow rate.

The numerical values of those parameters will be governed by the performance data reported by the applicant. The trial burn (or alternative) data should include values for these operating parameters which correspond to the performance level achieved in the trial burn. Therefore, at a minimum, a set of values for carbon monoxide in the stack gas, waste feed rate or thermal input rate, combustion temperature and combustion gas flow rate should be reported for a corresponding destruction and removal efficiency, mass emissions of HCl and/or scrubber removal efficiency, and emissions of particulate material.

The applicant should report values for each operating parameter which include information regarding normal fluctuations. The permit requirements can be written to incorporate the range identified. This may be accomplished in several ways. For example, the operating parameter values may be reported as a range (e.g., 1800 ± 50°F), or the applicant may provide the actual readout from the monitoring instrument which shows fluctuations over time. Submission of readouts from continuously monitoring instrumentation is recommended. Examples of interpretation of such data is provided in Chapter 5.

The maximum amount of information can be generated by testing each of the operating parameters at several levels during the trial burn. If each level is reported along with a description of the fluctuation that occurred, the applicant will have established a wide range of conditions over which adequate performance is achieved. Permit conditions for each parameter may be expressed as the ranges tested successfully during the trial burn. This approach provides the operator with a high degree of flexibility during routine operation.

4.1.1 Carbon Monoxide Level In The Stack Gas

The amount of CO present in combustion exhaust gas is a function of many factors, including combustion temperatures, residence time of the combustion gases at the combustion temperature, degree of mixing of fuel(s) and air, and the amount of air used in excess of stoichiometric requirements. These factors are interdependent to some extent; however, residence time and the degree of mixing of air and fuel(s) are primarily determined by the combustion chamber and burner design. Therefore, changes of CO concentration will reflect changes in excess air usage and in combustion temperatures.

The continuous measurement of carbon monoxide (CO) in the stack gas is useful for several reasons. CO concentration is a reliable indicator of combustion upset and remains a good indicator as excess air is lowered toward stoichiometric conditions and as combustion temperature is lowered. Additionally, carbon monoxide and carbon dioxide concentrations can be used to determine combustion efficiency.

Monitoring CO in the exhaust gas is most conveniently done in the exhaust stack, where temperatures are low. However, measurement of CO at other points in the system is acceptable. For example, CO may be measured in the take-off ducting immediately after the combustion chamber or afterburner.

The permit writer should specify, as the maximum allowable CO concentration, the maximum CO concentration reported from the trial burn demonstrating compliance with the performance standards. However, some allowance for normal variation may be specified in the permit in order to protect against unnecessary activation of the waste feed cutoff system. Following the trial burn, the applicant should submit the actual readout from the CO monitoring device. This chart will provide data describing the average CO concentration and the frequency, magnitude and duration of any downward or upward spikes. Permit conditions that accomodate some degree of fluctuation in the stack gas CO concentration can then be selected on the basis of this information.

4.1.2 Waste Feed Rate

The waste feed rate may be effectively controlled by stipulating the maximum total thermal input rate to the incinerator. The permit writer is encouraged to specify the maximum total thermal input rate (e.g., Btu per hour) including the heating values contributed by hazardous waste, non-hazardous waste and auxiliary fuel, in all permits. In conjunction with specifying the minimum heating value of the waste feed, control of the thermal input rate will ensure that the incinerator is not overloaded with difficult to incinerate hazardous constituents and that compliance with the performance standards is maintained. Because the total thermal input is derived from trial burn data, the applicant gains greater flexibility in a permit by operating at the maximum thermal input that at a lesser thermal input during a trial burn. Turndown, or reduced thermal input to an incinerator, from the maximum permitted value is allowable if compliance with the other permitted operating conditions is maintained. Additional restrictions on the waste feed rate may be imposed by specifying a mass or volume feed rate of the waste (e.g., pounds per hour, gallons per hour).

Some incinerators have multiple waste feed locations. The permit writer may include restrictions on wastes fed at certain locations to insure a minimum residence time in the incinerator. Similar restrictions may be placed on the quantity of wastes containing very toxic constituents that may be fed to an incinerator.

The following example illustrates specification of both the total thermal input and a mass feed rate.

Tetrachloroethylene is the most difficult POHC to incinerate present in Waste A. Waste A is successfully incinerated during a trial burn at a feed rate of 100 lb/hr, using 100 lb/hr of auxiliary fuel. If the heating value of Waste A is 5000 Btu/lb and that of the auxillary fuel is 18,000 Btu/lb, the total thermal input is 2.3 million Btu/hr. The permit may be written specifying the maximum feed rate and minimum heating value of Waste A, and the maximum allowable total thermal input, 2.3 million Btu/hr for more easily incinerated wastes. Thus, Waste B, having heating value of 10,000 Btu/lb and all hazardous constituents easier to incinerate than tetrachloroethylene, may be fed to the incinerator at rates up to 230 lb/hr if no auxilliary fuel is burned. Alternatively, the incinerator can be operated co-burning 100 lb/hr of Waste A and 180 lb/hr of Waste B to achieve the maximum thermal input of 2.3 million Btu/hr. The net effect of specifying the total thermal input is to permit the substitution of easily incinerated waste for auxilliary fuel if specified operating conditions, such as combustion zone temperature and air feed rate, are maintained. Additional examples of specifying the total thermal input are provided in Chapter 5.

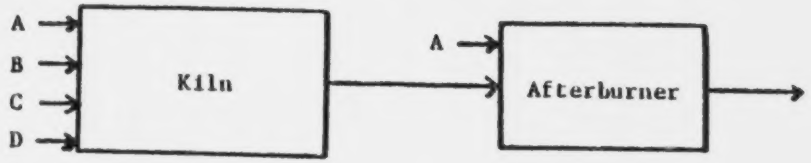
Specification of waste feed as mass feed rate of the POHCs will generally not be necessary. Such a permit condition would require frequent analysis of incoming wastes and feed tank blends in order to ensure permit compliance. The permit limitations on other operating parameters fix the temperature, residence time and heating value of the waste, reducing the need for feed rate stipulations based on mass input of the POHCs.

Waste compositions are specified in a permit for each waste or waste mix having a different physical state. The permit writer has the option of developing permit conditions for wastes with the same physical state, entering the incinerator at the same location, as separate wastes or as a single waste mix. The physical states of wastes in the form they enter the incinerator are classified as pumpable liquids, non-pumpable or solid materials, and containerized wastes. Pumpable liquids include pumpable slurries and highly aqueous wastes. Non-pumpable wastes include sludges, tars, and solid materials having high ash contents. The definition of wastes having different physical states as separate wastes in a permit is necessary to ensure adequate volatilization of the hazardous constituents from a waste prior to flame oxidation. For example, the volatilization of hexachlorobenzene from a liquid solvent atomized in a burner is much faster than the volatilization of hexachlorobenzene from a still bottom tar. Accordingly, the maximum mass loading rate that may be incinerated in compliance with the performance standards of the liquid waste is likely to be much greater than that of the sludge and the permit must take these factors into account.

Waste feed locations are specified in a permit in order to ensure adequate retention time in the combustion chamber. Waste feed locations upstream of those used during a satisfactory performance test provide additional residence time in the combustion chamber and generally are permissable. Downstream feed locations may decrease effective residence time and should not be permitted because the DRE may be lowered out of compliance.

Wastes having the same physical state fed to the incinerator at the same location may be regarded as one waste in a permit. The permit writer has the option to consider such wastes a waste mix and specify the mixed waste composition in a permit. Alternatively, the composition of each waste stream may be specified in the permit. The applicant may prefer one of the options and the permit writer should prepare the draft permit accordingly.

The specification of wastes of different physical form and multiple feed locations is illustrated using the example in Figure 4-1. Assuming that all the performance test results are in compliance, wastes C and D must be defined in the permit separately because the physical states are not the same. The incinerator charging rate may be specified on the basis of total thermal input, or the combination of thermal input and mass input rates. If mass loading rate is used, the permit would specify that 600 lb/hr of waste C having a minimum heating value of 7000 Btu/lb and a maximum organically bound chlorine content of 6 percent may be fed to the kiln. 600 lb/hr of waste D having a minimum heating value of 8000 Btu/lb and a maximum organically bound chlorine content of 10 percent may be fed to the kiln. Specifying the total thermal input, no more than 4.2 million Btu/hr of waste C and no more



Waste Feed Locations

Waste Characteristics

Waste Waste	Physical State Physical State	Feed Rate (lb/hr)	Heating Value (Btu/lb)	Organically Bound Chloride Content (%)
A	Liquid	400 to afterburner 600 to kiln	10,000	15
B	Liquid	500	2,000	3
C	Solid	600	7,000	6
D	Drummed	600	8,000	10

FIGURE 4-1

EXAMPLE OF MULTIPLE WASTE FEEDS TO A ROTARY KILN INCINERATOR than 4.8 million Btu/hr of waste D may be fed to the incinerator. Wastes C and D must be fed to the kiln and may not be fed to the afterburner in order to ensure sufficient residence time.

Wastes A and B have the same physical state and both are fed to the kiln. Only Waste A is fed to the afterburner. The waste composition may be specified in a number of ways. Wastes A and B may be considered a waste mix entering the kiln (see the example above) and the total allowable waste fed to the kiln includes the amount of waste A fed to the afterburner. Waste B may not be fed to the after-burner. The permit would specify that 1500 lb/hr of liquid waste having a minimum heating value of 7400 Btu/lb, and for no more than 11.1 million Btu/hr of liquid waste, having a maximum organically bound chloride content of 11 percent may be fed to the kiln. Another option is that Wastes A and B may be considered a waste mix to the kiln and may include Waste A to the afterburner, if operating conditions for the afterburner are stipulated separately. Weighted averages may be used to establish the heating value and chloride content. The permit would also specify that 400 lb/hr of waste A may be fed to the afterburner with a minimum heating value of 10,000 Btu/lb and a maximum organically bound chloride content of 15 percent.

The other method to develop the permit is to define wastes A and B separately at each feed location, using mass feed rate or total thermal input. Using the mass feed rate for example, 400 lb/hr or waste A can be fed to the afterburner, 600 lb/hr or waste A can be fed to the kiln, and 500 lb/hr of waste B can be fed only to the kiln. Waste A must have a minimum heating value of 10,000 Btu/lb and a maximum organically bound chloride content of 15 percent. Waste B must have a minimum heating value of 2000 Btu/lb and a maximum organically bound chloride content of 3 percent.

4.1.3 Combustion Temperature

The permit needs to specify a minimum allowable combustion temperature. This value should be the minimum temperature shown during the trial burn, or by alternative data, to correspond with achievement of the required performance standards. Specification of a maximum allowable combustion temperature is not necessary because increased temperatures presumably increase destruction efficiency. Furthermore, the maximum temperature at which the incinerator will be operated is limited by refractory capabilities and other design considerations.

In setting the requirement for minimum allowable combustion temperature, the permit writer should consider temperature fluctuations encountered during the performance test. The heated refractory will act to maintain thermal stability and temperature fluctuations should not be great. However, some allowance for normal variations is needed in order to protect against unnecessary activation of the waste feed cutoff system as a result of temperature "spiking" (see Section 4.1.5). Examples of the specification of minimum permitted operating temperature are provided in Chapter 5.

Consideration must also be given to the location of the temperature sensing device. In many instances, temperature sensors will be located at several points in the system. The reported temperature should be measured at the point where the data will be most representative of the gas temperature as it exits in the combustion chamber. Although the exact location of the temperature sensor will vary in each case, a location should be specified in the permit in order to ensure that temperature is always monitored at the same point in the system during routine operation.

4.1.4 Combustion Gas Flow Rate

Combustion gas velocity is an indicator of the flue gas volume flow rate, which is a function of thermal input to the incinerator, gas temperature, and excess air usage. Measurement of combustion gas flow rate provides a good indication of residence time in the combustion zone.

The maximum combustion gas velocity (or exit gas velocity) shown during the trial burn (or by alternative data) as corresponding to achievement of the required level of performance should be designated as the maximum allowable velocity. Specification of a minimum velocity is not necessary since the required performance should be maintained at turndown provided that all other operating parameters are maintained. The permit writer should recognize that incinerators burning containerized wastes may exhibit sharp momentary increases in combustion gas velocity ("puffing") upon charging. Such variations should be incorporated into the permit conditions if sufficient performance data are supplied.

Combustion gas flow rate may be measured by many different means. Combustion gas velocities may be measured using orifice plates or veturis, pitot tubes, or by indirect means. Orifice plates and venturis are impractical for combustion gas velocity measurements because of the large pressure drops caused by these devices. Pitot tubes may be used to measure combustion gas velocity in the hot zone of an incinerator immediately downstream of the combustion chamber or in cooler areas, such as the stack. Pitot tube measurements can be converted to combustion gas velocity and volume flow rate using the procedure in EPA Method 2 presented in the Appendix of 40 CFR 60. Changes in the molecular weight and the water content of the combustion gas will affect the correlation of pitot tube measurements and combustion gas velocity.

Indirect measurements of combustion gas velocity may include blower rotational speed and current draw. Many blowers operate in the region of the blower curve where static pressure and current draw (horsepower) do not change radically with a change in capacity. Therefore, blower static pressure and current measurements are generally not suitable indicators of combustion gas velocity unless the applicant can demonstrate a reliable correlation. Blower rpm is indicative of combustion gas velocity and volume flow rate only if static pressure in the blower remains constant. Measurement of combustion gas velocities using blower characteristics on incinerators equipped with more than one blower may become very complex, and the problems may be alleviated by use of a pitot tube method instead.

Measurement of pressure differentials across incinerator components, such as combustion chambers and air pollution control devices, is not a suitable indicator of combustion gas velocities. Pressure differentials may be affected by leakage, changes in liquid flow rates, and clogging phenomena as well as gas flow rates. It is not usually possible to distinguish the factors affecting changes in pressure measurements using conventional equipment. Therefore, pressure differential measurements should not be used as gas velocity indicators; however, they may be useful monitors for upset conditions.

Continuous monitoring of the oxygen concentration in the stack gas is an acceptable substitute for combustion gas velocity measurement. The oxygen concentration is indicative of excess air usage and, if waste feed composition and feed rate remain constant, it is an indirect measurement of the combustion gas volume flow rate. The most common method of continous oxygen measurement is an electro-catalytic device, and paramagnetic and polarographic instruments are used. The monitors are either in-situ or extractive. Additional information about instrument capabilities is presented in the Engineering Handbook.

4.1.5 The Emergency Waste Feed Cutoff System

The purpose of the automatic waste feed cutoff system is to shut off waste feed to the incinerator whenever the operating parameters deviate from the limits set in the permit. For this reason, the cutoff valve should be interlocked to all of the required continuous monitoring devices. These devices include monitors of temperature, combustion gas velocity, and carbon monoxide level in the stack gas. For each of these parameters, the permit should include a provision that establishes both a range for operation and a level, somewhat beyond that range, at which the emergency waste feed cutoff system must be activated. The following discussion provides an example for proper integration of the waste feed cutoff system with the combustion temperature monitor. Similar approaches may be taken for integration with other operating parameters as well.

Following the trial burn, the applicant should submit the actual readout from the temperature recording device. This chart will provide the permit writer with data describing the average operating temperature and the frequency, magnitude and duration of any downward or upward spikes. Effective permit conditions can be selected on the basis of these data. Generally, the permit will specify that the incinerator be operated at or above the average temperature tested during the trial burn. Additionally, the permit should specify that the automatic waste feed cutoff be activated at a lower temperature than the range of normal fluctuation indicated by the results of the trial burn.

This cutoff temperature may be selected in several ways, each of which requires some degree of judgment. The automatic cutoff temperature may be selected by calculating a time-weighted average of the temperatures recorded below the target operating temperature. Alternatively, the permit writer may select the temperature of the lowest spike as the automatic cutoff temperature. In this case, however, a rarely occurring, very large downward spike should be considered unrepresentative of normal temperature fluctuation and should be disregarded. The permit condition might also be written to establish an automatic cutoff which allows for momentary excursions by specification of allowable excursion magnitude, frequency and duration. Conceptually, this type of control could best be accomplished using a system which would limit the total number of degree-minutes below a prescribed level before activation of the waste feed cutoff mechanism. Such a system, however, will not always be available for use by the operator. The necessary limits for such a system would vary from case to case. The permit writer should require that detailed information regarding temperature fluctuations be provided. When selecting the actual limit on degree-minutes of deviation, the permit writer should generally allow deviations to occur for only a small fraction of the total operating time. This approach is advantageous because it allows for the possibility of very large, but infrequent and brief downward spikes without activation of the automatic waste feed cutoff. This concept is illustrated in Section 5.1.2.

4.2 Limitations On Waste Feed Composition

Permit limitations on waste feed composition should address two aspects of the waste: allowable waste constituents and chemical and physical waste characteristics. The actual limitations selected for these parameters depends on the results of the trial burn. Permit conditions regarding allowable waste constituents are restricted to limitations on those substances listed as hazardous constituents in Appendix VIII of 40 CFR Part 261.

Limitations on the physical and chemical characteristics of the waste feed may be used, rather than stipulations on allowable POHC concentrations. Theoretically, incinerator DRE performance is independent of POHC concentration, provided that limitations are placed on the other physical and chemical characteristics of the waste and on the incinerator operating parameters. However, in practice, this approach will be most reliable if the trial burn is conducted using the largest POHC concentrations anticipated during normal operation. Guidance for selecting limitations on chemical and physical characteristics is presented in this section.

The method described for restricting waste feed composition has been designed to minimize the burden of time consuming and complex chemical analysis. This is accomplished by using operating requirements and restrictions on physical and chemical characteristics of the waste to ensure adequate performance.

4.2.1 Allowable Waste Feed Constituents

The number and identity of allowable hazardous waste constituents specifed in the permit will depend primarily on the waste constituents burned during the trial burn and on their placement on the hierarchy of incinerability (presented in Chapter 2). The principle which should govern writing the permit is that allowable hazardous constituents are those which exhibit higher heat of combustion values (i.e., those which are easier to burn) than the POHCs for which the required performance was shown either in a trial burn or by alternative data. In this way, the determination of allowable hazardous constituents can be derived directly from the hierarchy of incinerability.

In practice, this approach allows the applicant to control the number of hazardous constituents which the permit will allow him to burn (and hence, the range of wastes which can be accepted for treatment at the facility) through careful design of the trial burn. If a wide range of flexibility is needed, the trial burn should be conducted using a waste containing significant levels of POHCs having very low heat of combustion values. The permit would allow burning of wastes containing constituents which are easier to incinerate if compliance with the performance standards is demonstrated.

After successful completion of a trial burn, it is not necessary that the permit writer automatically allow burning of all constituents, without regard to their concentration in the waste, which fall below the trial POHCs on the hierarchy. The permit writer may deem certain exclusions or restrictions on concentration necessary. Such restrictions should be considered in cases where a substance known or suspected to be a highly potent human toxicant (e.g., 2,3,7,8-TCDD) falls below the trial POHC on the hierarchy.

In order to maximize flexibility of the permit conditions regarding allowable waste feeds, the applicant may burn a contrived waste during the trial burn which has been spiked with one or several POHCs known to be difficult to destroy. In such a case, the applicant will gain flexibility in terms of allowable hazardous constituents (and, therefore, waste feeds). However, since compliance is established at conditions sufficient to destroy the most difficult POHC to incinerate, the permit will require that all wastes be treated under these same conditions.[1]

In cases where a contrived waste is used during the trial burn, the permit writer should also consider concentration of the POHCs in the trial waste. The contrived waste should contain POHCs in concentrations which are representative of concentrations expected to be found in the actual wastes managed at the facility. Spiking the trial waste with POHCs in concentrations which are somewhat higher or in the upper range of concentrations expected to be encountered during routine operation will provide greater assurance that the operating requirements will be sufficient to achieve compliance with the performance standards. In all such cases, very large differences between the trial POHC concentrations and the expected waste concentrations should be avoided, and the concentration of POHCs in the trial burn waste should always be greater than or equal to the POHC concentrations expected during routine operation.

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[1] As described in Chapter 2, this situation may be avoided if the applicant groups the wastes according to incinerability and establishes a set of operating conditions for each group of wastes. In such a case, a trial burn would be necessary to show the required performance for the most difficult to destroy POHC(s) from each waste group.

4.2.2 Limitations On Chemical And Physical Waste Feed Characteristics

In addition to specification of allowable waste constituents, the permit should set appropriate limits on the chemical and physical properties of the permitted waste(s). The parameters for which limits should be set include, at a minimum:

- Heating value
- Ash content
- Organically bound chloride content
- Physical characteristics (e.g., physical state).

These limitations, together with the operating requirements discussed in previous sections (in particular, stipulations on waste feed rate), limit operations to such an extent that the performance level demonstrated during the trial burn should be achieved and maintained during routine operation.

4.2.2.1 Heating Value

Knowledge of the waste feed heating value is necessary to maintain a relatively constant thermal load to the incinerator thereby resulting in stable combustion zone conditions. Gross decreases in the heating value of liquid and gas feed streams may indicate major changes in the concentration of hazardous constituents, which would make the waste more difficult to incinerate. Additionally, a permit condition for waste heating value may be used to convert the waste feed rate from units of mass per unit time to Btu's per unit time. Stipulation of waste feed rate in this manner will be advantageous in cases where the operator normally controls heat content of the waste feed in order to maintain stable combustion conditions. The lowest heating value for liquids and gases shown to correspond with the required performance level, either during a trial burn or by alternative data, should be designated in the permit as the lowest allowable heating value.

A lower limit will also encourage blending of liquid waste feeds which contributes to steady, consistent operation of the incinerator. An upper limit on heating value of liquids and gases is not necessary because wastes with higher heating values are presumably more easily burned.

When waste streams to be burned cannot be adequately blended as in the case with high water content wastes and many organic wastes, blending to meet a lower permit limit becomes impractical. Since these wastes, if mixed, would form separate phases and introduce undesirable upsets in heat release, it becomes necessary to inject "water" wastes separately. In this situation a minimum heating value on a stream consisting primarily of water would be of little value, but the Btu value of the separate streams when averaged together should still meet a specified limit. The permit writer, when evaluating the separate injection of water waste, must be aware of the potential for flame quenching of the higher heating value waste. In approving the trial burn plan and developing final permit conditions, the permit writer must exercise caution to avoid flame quenching situations or be aware of their impact. Careful design of the trial burn conditions to reflect the worst case situation is the key to avoiding or minimizing problems of flame quenching.

However, in the case of solids fed to rotary kilns, hearths and other solids handling incineration equipment, a different approach to specifying a heating value for waste is needed. Many solid wastes, by their very nature, are subject to wide variations in heating value, and rotary kiln, hearth, and similiar incinerator designs attempt to deal with this problem. Such designs provide for the volatiles in the solids to be vaporized and subsequently destroyed in an afterburner or secondary combustion chamber. Thus in specifying heating values for solid waste feeds, a lower heating value limit may not be required if the incinerator is equipped and operated to maintain sufficient temperature by addition of liquid waste or auxiliary fuel.

The permit writer, in evaluating incinerators handling solids, should be aware of a different problem related to the heating value of solids. Many solids, including drummed materials, can cause sudden increases in heat release in an incinerator. Such sudden increases can result in overpressuring in negative pressure systems (puffing) and oxygen deficient combustion conditions. This results in fugitive emissions and incompletely combusted materials in the stack effluents. In setting heating value limits for solids fed, the permit writer may consider placing an upper limit on the quantity of waste in each drum on a mass or Btu basis and/or limiting the rate at which solids and drums can be charged to the incinerator.

4.2.2.2 Ash Content

Specification of the maximum allowable ash content will, to some extent, ensure that the particulate removal capability of the air pollution control system is not exceeded during normal operation. Only a maximum allowable level need be specified. Because ash content and exhaust gas particulate load do not correlate directly, this permit condition is not intended as a direct means of controlling particulate emissions. Rather, it is intended to provide an indication that, with respect to ash content, the waste feed to the incinerator remains similar to that tested during the trial burn.

Specification of an effective permit condition for ash content will be particularly difficult when the trial burn waste is contrived by blending wastes or chemicals. In such cases, the contrived blend should contain a material (such as fly ash) suitable for simulating a particulate load that is equal to or greater than that expected during routine operation. Several factors should be considered when selecting an appropriate material for this purpose. They include particle size distribution, mean particle diameter, the resistivity of the material, the degree to which it may react with the stack gas (and influence the DRE), and the design of the particulate collection device. The waste feed selected for use in the trial burn should contain ash at levels similar to or higher than those expected during normal operation.

4.2.2.3 Organically Bound Chloride Content

The organically bound chloride content of a waste may be correlated with scrubber performance. In order to avoid overloading the scrubber and possibly exceeding the hydrogen chloride emission standard, the maximum allowable organically bound chloride concentration should be that for which compliance with the performance standard has been demonstrated. Lower organically bound chloride concentrations in the waste are allowable variations.

4.2.2.4 Physical Characteristics

Changes in the physical state of the waste feed can result in changes in incinerator performance. The permit should therefore limit the physical state of the waste to that of the trial burn waste. Precise guidance for establishing limits on physical characteristics is not provided because determinations will be highly case-specific and will require application of engineering judgement. The following discussion provides a specific example which might be used for comparative purposes.

An incinerator having both liquid injection and rotary kiln capabilities may effectively treat liquid, solid and sludge wastes. Furthermore, any of these wastes might be fed to the incinerator in containers. The trial burn should be conducted such that the POHCs are introduced in the physical form in which they are likely to be received during routine operation. The permit should then restrict the allowable physical form to that used during the trial burn.

If containerized hazardous wastes are to be burned, the permit writer should consider the need to limit the condition or construction of the drums as they enter the combustion zone. For example, when closed steel drums are fed to a rotary kiln incinerator, explosion of the drums inside the kiln may result in "puffing", or release of highly concentrated emissions from the kiln. The permit, therefore, might specify that drums be opened or punctured immediately prior to charging in order to minimize puffing. However, if the trial burn demonstrates that introduction of closed drums does not result in puffing, the requirement that drums be opened may not be necessary.

4.3 Specification Of Inspection Requirements For The Emergency Waste Feed Cutoff System

The incinerator regulations require weekly testing of the automatic waste feed cutoff system. Monthly testing may be allowed in cases where the applicant has shown that weekly testing will be highly disruptive and that monthly inspection is sufficient. This test is intended only to verify operability of the emergency waste feed cutoff system and should not require dismantling of equipment or unscheduled calibration of sensors.

Complete shutdown of the incinerator is not necessary for testing the feed cutoff valves or devices and the associated safety system. The valves may be checked while waste is input to the incinerator and the potential for creating upset conditions are at a minimum. The valve needs to be activated only once during an inspection; a check of every input to the safety system does not have to activate the valve. Additionally, if the valve is "fail safe" (i.e., it fails in the closed position), only the control panel circuits and associated alarms need weekly testing; the valve need not be activated. Since cut off valves are designed to operate for over one million cycles, testing should not be considered to contribute significantly to wear. Detectors and sensors are generally connected to the cut off valve through relays, which are often equipped with an integrated test circuit.

The permit writer should specify the inspection requirements on a case-by-case basis. Although safety system design is fairly standard due to insurance requirements, the following factors should be taken into account before specifications of a schedule for testing:

- Extent of integration of the incinerator with other on-site processes. If the incinerator is closely integrated, testing is likely to be complex and time consuming.
- Installation of multiple burners. Incinerators with more than one liquid waste burner will be better able to maintain thermal input to an incinerator as the cutoff value to each burner are tested.
- Presence of a solid waste loading system. Momentary cut off during inspection of a conveyor belt, screw feeder, or hydraulic ram should not upset incinerator conditions because such feed systems are not likely to be the only source of thermal input.
- Availaibility of test circuits. Checks and inspections of safety systems equipped with test circuits, test jacks, and signal simulators are easily performed and may not require the presence of an instrument mechanic.
- Safety system design. The more complex a safety system is, the longer it will take to check. Also, if accessability to system components is a problem, a system check is further complicated.

When evaluation of these factors indicates that weekly inspection may be impractical, alternatives may be considered. For example, weekly inspection might be limited to testing the waste feed cutoff valve and more comprehensive testing of the system (e.g., verifying operability of alarms, sensors and associated control circuitry) could be conducted at longer intervals. Such a minimum weekly inspection could involve triggering of the waste feed cutoff valve by a simulated low combustion chamber temperature. This test should be conducted by properly trained personnel, e.g., an instrument mechanic. Should the test reveal that the system is not functioning properly, the permit should require that the waste feed be cutoff immediately and the necessary repairs made.

A second approach to inspection of the waste feed cutoff system might involve weekly testing of the valve and rotational testing of the control circuitry which interlocks the valve with the various control parameter monitors. For example, during Week 1, the valve might be activated by inducing a low temperature condition. During Week 2, a high carbon monoxide level might be used to activate the valve. This would be followed, in Weeks 3 and 4, by activation of the circuitry interlocked to the gas flow velocity monitor and any other continuous monitoring devices. This inspection method incorporates weekly testing of the cutoff valve(s) with rotational (monthly, or bimonthly) testing of the system components.

Daily incinerator inspection may be limited to visual examination for leakage, spills, corrosion, hot spots and malfunctions. The inspection should reveal whether gauges, recorders, and monitors are functioning and if there are any signs of tampering with incinerator equipment. Visual inspection should also identify needs for repair.

5.0 EXAMPLES OF SPECIFICATION OF PERMIT CONDITIONS

The examples of the specification of permit conditions provided in this chapter are intended to illustrate some of the approaches to permitting discussed in this manual.

Example 1: The first example demonstrates the development of permit conditions for an on-site incinerator dedicated to burning one hazardous waste under one set of operating conditions. This permitting situation is straightforward and is used to illustrate the development of permit conditions from performance results and the interpretation of engineering data.

Example 2: The second example illustrates the permitting of a hearth incinerator burning a solid waste and a liquid waste at one set of operating conditions. The purpose of this example is to demonstrate how a permit is written to allow the incineration of more than one hazardous waste and how the maximum thermal input is used to limit waste feed rates.

Example 3: In the third example, two hazardous liquid wastes are co-incinerated with a solid waste mixture and the incinerator operating conditions depend on which liquid wastes are being co-incinerated. The third example illustrates the permitting of incineration of specific hazardous wastes at specific operating conditions and the use of the waste grouping concept.

The examples in this chapter address the specification of waste composition and incinerator operating conditions from selected data appearing in a Part B application and do not include the specification of other provisions that must be included in a permit, such as monitoring, safety, and inspection requirements. Each example in this chapter is summarized in two tables; one table contains the trial burn data that comprise part of the permit application and the other table lists the permit conditions developed from these data. The combustion zone temperature is used as a surrogate for all continuously monitored operating parameters such as combustion gas velocity and carbon monoxide concentration in the stack gas. The final permit must specify each of these parameters. It is assumed that all numerical values have been checked and found acceptable.

5.1 Discussion of Example 1

5.1.1 Case Description

Sample permit application data are listed in Table 5-1. The incinerator is a single chamber liquid injection unit integrated with a production process. The waste stream to be incinerated is fairly consistent in terms of waste quantity and composition. The heating value ranges from 8000 to 10,000 Btu/lb, and the applicant used a waste sample with 8000 Btu/lb for the trial burn. Of roughly a dozen Appendix VIII constituents that were present based on waste analysis data submitted with the permit application, three POHCs were selected for the trial burn: dioxane (heat of combustion 6.41 kcal/gm); ethylene oxide (heat of combustion 6.86 kcal/gm); and phenol (heat of combustion 7.78 kcal/gm). The concentrations of these POHCs in the waste were the following: dioxane 3%; ethylene oxide 5%; phenol 20%. The applicant indicated that concentrations of each constituent varied not more than ±25% from these values. The waste analysis showed chloride content and ash content of 0.5% and 0.8% respectively. For the trial burns the applicant proposed two operating conditions, one targeted at 2100°F, the other at 2300°F.

The applicant could have built additional flexibility into his permit by extending his trial burn to include waste having lower heating value, higher ash or chlorine content, or additional POHCs more difficult to incinerate than dioxane.

5.1.2 Development of Permit Conditions

The results of the trial burn are shown in Table 5-1. The trial burn at 2100°F achieved 99.99% DRE only for phenol. The trial burn at 2300°F achieved

TABLE 5-1

SAMPLE PERMIT APPLICATION DATA - EXAMPLE 1

Incinerator: Single Chamber Liquid Injection

Waste Characterization Data

	Waste 1
Physical State	Liquid
Heating Value	8,000-10,000 Btu/lb
Organically-Bound Chloride Content	<0.5%
Ash Content	<0.8%
POHCs	Dioxane Ethylene oxide Phenol

Two trial burns were conducted generating the following data:

Incinerator Operating Conditions

	Test 1	Test 2
Waste Feed Rate - Waste 1	600 lb/hr	600 lb/hr
Combustion Chamber Temperature		
Primary Secondary	See Figure 5-1	
Waste Feed Location	Primary	Primary

Trial Burn Results

	Test 1	Test 2
DRE - Dioxane	99.97%	99.99%
Ethylene oxide	99.984%	99.992%
Phenol	99.991%	99.995%
Particulate Emissions*	0.075 gr/dscf	0.068 gr/dscf
HCl Emissions	<4 lb/hr	<4 lb/hr

* at 50% excess air

99.99% DRE for all three POHCs. The particulate and HCl emissions were in compliance in both trial burns. The resulting permit conditions are shown in Table 5-2. (Note: Limits on air feed rate and CO in the stack gas are not shown in this example, but they would be derived directly from trial burn conditions.)

The derivation of the permitting operating temperatures from the continuously recorded combustion zone temperature is very important in this example. Samples of the recorded temperatures from each performance test are presented in Figure 5-1. The mean temperature during Test 1 was 2160°F based on temperatures measured at 15-minute intervals. Because there were three temperature spikes which lasted over 45 minutes of this 7-hour performance test, a mean value obtained at less frequent intervals might be skewed. Ideally, the mean temperature should be obtained from measurements at more frequent intervals. Although the temperature increased approximately 200°F during the trial burn, the amount represents an increase of less than 10 percent. The temperature spikes account for approximately 10 percent of the time of the performance test. Considering both of these values, the incinerator is probably operating at steady state conditions. If the values were considerably less than 10 percent deviations, steady state conditions would definitely exist. If the deviations were greater than 15 percent, the incinerator would probably not be operating at steady state.

Specification of the allowable temperature range for Test 1 is difficult. The standard deviation of the Test 1 temperatures at 15 minute intervals is 121°F. The standard deviation might be used to establish the allowable temperature range; however, the deviation increases as the incinerator approaches non-steady state conditions, which should not be permitted. If the incinerator operates at ideal steady state conditions, use of the standard

TABLE 5-2

SAMPLE PERMIT CONDITIONS - EXAMPLE 1

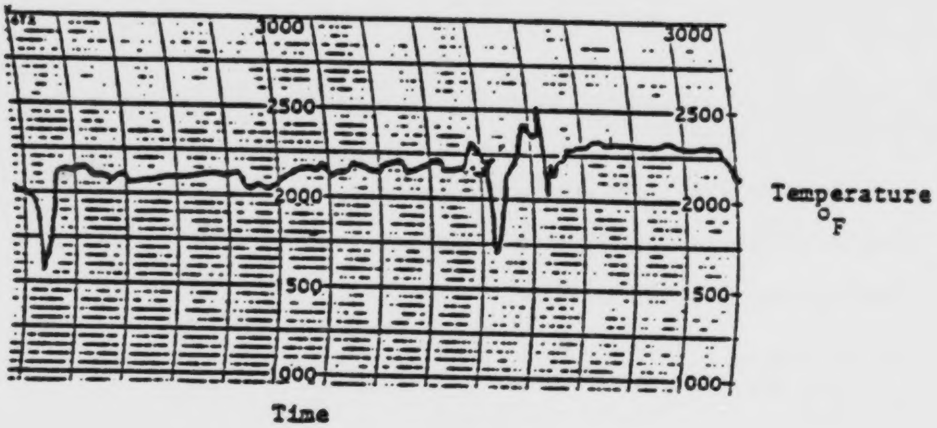
- The permittee is allowed to burn liquid hazardous wastes with the following composition:
  - Minimum heating value is 8,000 Btu/lb
  - Maximum organically bound chloride content is 0.5%
  - Maximum ash content is 0.8%
  - No hazardous constituents more difficult to incinerate than dioxane using the heat of combustion hierarchy may be incinerated at Condition 1 defined below
  - No hazardous constituents more difficult to incinerate than phenol using the heat of combustion heirarchy may be incinerated at Condition 2 defined below

- The following incinerator operating conditions must be maintained subject to the previous stipulations:

Condition 1:
- The waste feed rate must be no more than 600 lb/hr
- The minimum allowable combustion zone temperature is 2150°F measured at (specify location of temperature sensing device used during the performance test); at lower temperatures, the waste feed cut off system must be activated

Condition 2:
- The waste feed rate must be no more than 600 lb/hr
- The minimum allowable combustion zone temperature is 1950°F measured at (specify location); at lower temperatures, the waste feed cut off system must be activated

Test 1



Test 2

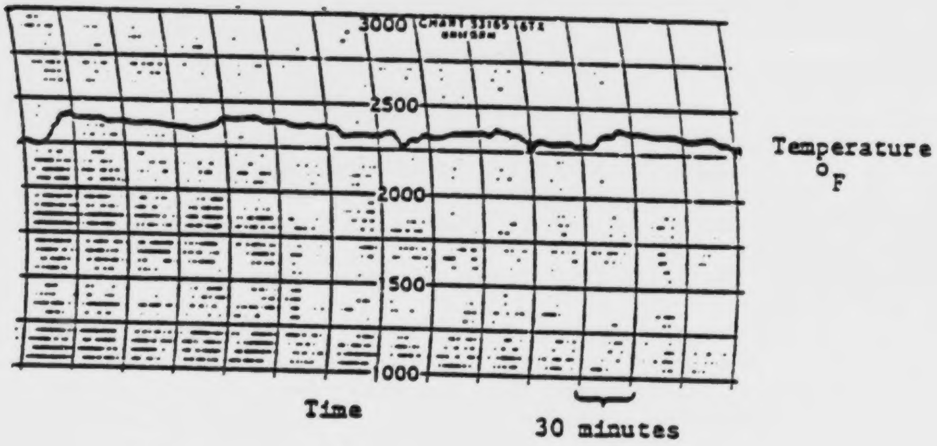


FIGURE 5-1

SAMPLES OF CONTINUOUSLY RECORDED TEMPERATURES deviation might be overly restrictive. The purpose of allowing variations in operating conditions is to allow adjustments to maintain steady state conditions without activating the waste feed cut-off system. The potential problems of permitting unsteady state operation and confining operation too strictly may be avoided by allowing variations that are a fixed percentage of the mean or median temperature. In this example, a 10 percent variation from the mean temperature was allowed, permitting a minimum operating temperature of 1950°F. The permit writer should not specify the minimum operating temperature attained during a performance test as the minimum permitted temperature. The minimum temperature in this example was 1550°F and it is highly improbable that the same performance would be obtained at a mean temperature of 1550°F as at a mean temperature of 2160°F.

Steady state conditions were definitely achieved during Test 2; the temperature chart does not continually increase or decrease and there are no temperature spikes. The mean temperature measured at 15-minute intervals is 2350°F. The standard deviation is 45°F and if this value was used to specify the permit condition, it would be overly restrictive. As in the previous example, a deviation of approximately 10 percent is allowed, giving a minimum operating temperature of 2150°F. The records of other continuously monitored parameters may be evaluated similarly.

5.2 Discussion of Example 2

5.2.1 Case Description

Sample permit application data for the second example are presented in Table 5-3. The purpose of this example is to illustrate the permitting of mixed wastes and spiked wastes, and permitting on the basis of total thermal input. The incinerator in this example is a multiple chamber hearth burning a

TABLE 5-3

SAMPLE PERMIT APPLICATION DATA - EXAMPLE 2

Incinerator: Multiple Chamber Hearth

Waste Characterization Data

	Waste Blend 1	Waste Blend 2
Physical State	Solid	Liquid
Heating Value	5000 Btu/lb	80,000 Btu/gal
Organically-Bound Chloride Content	4-6%	<0.7%
Ash Content	10-25%	0.5%
POHCs	Phthalic anhydride Paraldehyde Phenol	Pyridine Toluene diamine Aniline

One trial burn was conducted generating the following data:

Incinerator Operating Conditions

	Test 1
Waste Feed Rate - Waste 1	200 lb/hr
Waste 2	15 gal/hr
Combustion Chamber Temp.	
Primary	1400-1600°F
Secondary	1750-1900°F
Waste Feed Location - Waste 1	Primary
Waste 2	Primary
Performance Results	
DRE - all POHCs	99.99%
Particulate Emissions	0.072 gr/dscf at 50% excess air
HCl Emissions	>4 lb/hr 99.2% removal efficiency

mixture of solid hazardous wastes and a mixture of liquid hazardous wastes.

The waste characterization data in this example are the results from the analysis of waste mixes comprised of several different hazardous wastes. Analytical data are provided on the two mixed wastes in the form each enters the incinerator. The data indicate that all solid wastes received at the facility are blended so that the heating value is greater than 5000 Btu/lb, the organically bound chloride content ranges from 4 to 6 percent, and the ash content is between 10 and 25 percent. Similarly, all non-halogenated liquid wastes are blended to achieve the stated values.

The POHCs present in the wastes are not considered very difficult to incinerate if the heat of combustion hierarchy is used. The applicant may spike these wastes with hazardous constituents more difficult to incinerate than phthalic anhydride and pyridene, particularly if the incinerator feeds are blended and such constituents may be present in future shipments of wastes. If the wastes are spiked, using less incinerable compounds such as maleic anhydride or nitroaniline, and satisfactory performance is achieved, the permit could be written to allow the incineration of wastes containing a greater number of hazardous constituents. Spiking wastes reduces the number of trial burns that might be necessary if wastes are received containing hazardous constituents that are more difficult to incinerate than those specified in the permit.

One trial burn was conducted with both hazardous waste mixes being fed to the incinerator simultaneously. The range of combustion chamber temperatures was determined using the method presented in Example 1. The trial burn performance results were in compliance with the regulatory requirements.

5.2.2 Development of Permit Conditions

The permit conditions developed from the trial burn data are presented in Table 5-4. Because the physical states of the waste mixtures are different, the permit must specify the compositions of two separate incinerator feeds. The permit conditions can be written directly from the waste characterization data and the incinerator operating information because the results of all the incinerator performance tests comply with the regulatory requirements. The permitted composition limits of waste blends are specified in the same manner as wastes from one specific source. The waste feed rates and other permit conditions may be specified in the units most conveniently monitored by the applicant.

Waste feed is restricted to the primary chamber. If the wastes were fed to the secondary chamber, the residence time would be decreased and satisfactory performance might not be achieved. The permit is written so that up to 200 lb/hr of Waste Blend 1 or 15 gal/hr of Waste Blend 2 may be fed to the primary chamber individually, or these amounts of the wastes may be incinerated simultaneously. Hazardous wastes containing more readily incinerated hazardous constituents than phthalic anhydride and pyridene may be fed in greater amounts, providing that the total thermal input is less than 2.2 million Btu/hr and the other permit restrictions on waste composition are satisfied.

TABLE 5-4

SAMPLE PERMIT CONDITIONS - EXAMPLE 2

- The permittee is allowed to incinerate the following hazardous wastes:

  Waste Blend 1:
  - The physical state of the hazardous waste must be solid
  - Minimum heating value is 5000 Btu/lb
  - Maximum organically bound chloride content is 6%
  - Maximum ash content is 25%
  - No hazardous constituent more difficult to incinerate than phthalic anhydride may be present in the waste

  Waste Blend 2:
  - The physical state of the waste must be a liquid
  - Minimum heating value is 80,000 Btu/gal
  - Maximum organically bound chloride content is 0.7%
  - Maximum ash content is 0.5%
  - No hazardous constituent more difficult to incinerate than pyridine may be present in the waste

- Waste Blends 1 and 2 may be incinerated together only if the following conditions are maintained:
  - The maximum feed rate of Waste Blend 1 is 200 lb/hr to the primary chamber at (specify location)
  - The maximum feed rate of Waste Blend 2 is 15 gal/hr to the primary chamber at (specify location)
  - The maximum thermal input to the incinerator is 2.2 million Btu/hr
  - The minimum combustion zone temperature in the primary chamber is 1400°F measured at (specify location)
  - The minimum combustion zone temperature in the secondary chamber is 1750°F measured at (specify location)

5.3 Discussion of Example 3

5.3.1 Case Description

The third example of developing permit conditions is a more complex variation of the second example, illustrating the correlation of incinerator operating conditions with waste composition in a permit. The sample application information is summarized in Table 5-5. The incinerator is a multiple chamber hearth unit burning solid waste and non-halogenated liquid waste mixtures as in the second example. A mixture of halogenated liquid wastes is also incinerated at different operating conditions and non-halogenated waste is fed to the afterburner to maintain high temperatures.

Two trial burns were conducted. The first trial burn was the same as the trial burn conducted in Example 2, where only the solid waste and the non-halogenated waste blends were incinerated. During the second trial burn, all three waste blends were fed to the primary chamber of the incinerator and the non-halogenated waste mixture was fed to the secondary chamber. Higher combustion zone temperatures were maintained during the second trial burn than during the first trial burn in order to ensure adequate destruction of the chlorinated materials. The results of both trial burns were in compliance with the regulatory performance standards.

5.3.2 Development of Permit Conditions

The permit conditions developed from the trial burn data are summarized in Table 5-6. The permit is similar to the one developed in Example 2 but includes additional operating requirements for the incineration of the halogenated waste blend.

One of the operating requirements is the restriction on waste feed location. Wastes may only be fed to the incinerator at the locations used during

TABLE 5-5

SAMPLE PERMIT APPLICATION DATA - EXAMPLE 3

Incinerator: Multiple Chamber Hearth Equipped with Liquid Injection

Waste Characterization Data

	Waste Blend 1	Waste Blend 2	Waste Blend 3
Physical State	Solid	Liquid	Liquid
Heating Value	5000 Btu/lb	80,000 Btu/gal	40,000 Btu/gal
Organically-Bound Chloride Content	4-6%	<0.7%	15-25%
Ash Content	10-25%	<0.5%	<0.5%
POHCs	Phthalic anhydride Paraldehyde Phenol	Pyridene Toluene diamine Aniline	Tetrachloroethane Hexachlorobenzene Hexachlorobutadiene

Two trial burns were conducted generating the following data:

Incinerator Operating Conditions

		Test 1	Test 2
Waste Feed Rate -	Waste Blend 1	200 lb/hr	150 lb/hr
	Waste Blend 2	15 gal/hr	15 gal/hr
	Waste Blend 3	0	10 gal/hr
Combustion Chamber Temperature			
Primary		1400-1600°F	1400-1600°F
Secondary		1750-1900°F	1850-2000°F
Waste Feed Location -	Waste Blend 1	Primary	Primary
	Waste Blend 2	Primary	Primary & Secondary
	Waste Blend 3	-	Primary

TABLE 5-5 (Concluded)

Performance Results

	Test 1	Test 2
DRE - all POHCs	99.99%	99.99%
Particulate Emissions	0.069 gr/dscf	0.076 gr/dscf
HCl Emissions	4 lb/hr >99.4% removal efficiency	4 lb/hr >99.8% removal efficiency

TABLE 5-6

SAMPLE PERMIT CONDITIONS - EXAMPLE 3

- The permittee is allowed to incinerate the following hazardous wastes:

Waste Blend 1:
- The physical state of the hazardous waste must be solid
- Minimum heating value is 5000 Btu/lb
- Maximum organically bound chloride content is 6%
- Maximum ash content is 25%
- No hazardous constituent more difficult to incinerate than phthalic anhydride may be present in the waste

Waste Blend 2:
- The physical state of the waste must be a liquid
- Minimum heating value is 80,000 Btu/gal
- Maximum organically bound chloride content is 0.7%
- Maximum ash content is 0.5%
- No hazardous constituent more difficult to incinerate than pyridine may be present in the waste

Waste Blend 3:
- The physical state of the waste must be a liquid
- Minimum heating value is 40,000 Btu/gal
- Maximum organically bound chloride content is 25%
- Maximum ash content is 0.5%
- No hazardous constituent more difficult to incinerate than tetrachlorethane may be present in the waste

TABLE 5-6 (Concluded)

- Waste Blends 1 and 2 may be incinerated only if the following conditions are maintained:
  - The maximum feed rate of Waste Blend 1 is 200 lb/hr to the primary chamber at (specify location used during performance test). Up to 750,000 Btu/hr of wastes containing more easily incinerated hazardous constituents, and satisfying the other permit conditions, may be fed at this location.
  - The maximum feed rate of Waste Blend 2 is 15 gal/hr to the primary chamber at (specify location used during performance test). Up to 1.2 x 10^6 Btu/hr of wastes containing more easily incinerated hazardous constituents, and satisfying the other permit conditions, may be fed at this location.
  - The minimum combustion zone temperature in the primary chamber is 1400°F measured at (specify location).
  - The minimum combustion zone temperature in the secondary chamber is 1750°F measured at (specify location).
- Waste Blend 3 may be incinerated only if the following conditions are maintained:
  - The maximum feed rate of Waste Blend 1 is 150 lb/hr to the primary chamber at (specify location used during performance test). Up to 750,000 Btu/hr of wastes containing more easily incinerated hazardous constituents, and satisfying the other permit conditions, may be fed at this location.
  - The maximum feed rate of Waste Blend 2 is 15 gal/hr, no more than 5 gal/hr of which may be fed to the secondary chamber at (specify location used during performance test). Up to 1.2 x 10^6 Btu/hr of wastes containing more easily incinerated hazardous constituents, and satisfying the other permit conditions, may be fed at this location.
  - The maximum feed rate of Waste Blend 3 is 10 gal/hr to the primary chamber at (specify location used during performance test). Up to 400,000 Btu/hr of wastes containing more easily incinerated hazardous constituents, and satisfying the other permit conditions, may be fed at this location.
  - The minimum combustion zone temperature in the primary chamber is 1400°F measured at (specify location)
  - The minimum combustion zone temperature in the secondary chamber is 1850°F measured at (specify location)

a satisfactory performance test. During Test 2 of this example, 10 gal/hr of Waste Blend 2 were fed to the primary chamber and 5 gal/hr were fed to the secondary chamber, or afterburner. Therefore, the permit conditions stipulate that no more than 5 gal/hr of Waste Blend 2 can be fed to the afterburner at the same location used during the performance test and Waste Blend 3 cannot be fed to the afterburner. If Waste Blend 3 was fed to the afterburner, the residence time in the incinerator would be less than if it was fed to the primary chamber, and a 99.99 percent DRE might not be attained. In the absence of performance data, it must be assumed that a 99.99 percent DRE will not be achieved and the permit is developed accordingly. Up to 15 gal/hr of Waste Blend 2 may be fed to the primary chamber because the residence time is increased if the waste is fed to the primary chamber instead of the afterburner. The increase in residence time will increase the DRE, and such operation is permitted.

Because of the restrictions on waste feed locations, the permit cannot be written on the basis of total thermal input to the incinerator. Maximum thermal inputs may be specified at each feed location, but unless significant amounts of auxiliary fuel were used during the performance test, the allowable feed rates of easily incinerated wastes will not be much greater than the feed rates used for the performance test. Table 5-6 demonstrates how the thermal input at each feed location may be specified in a permit.

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